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Monthly Report

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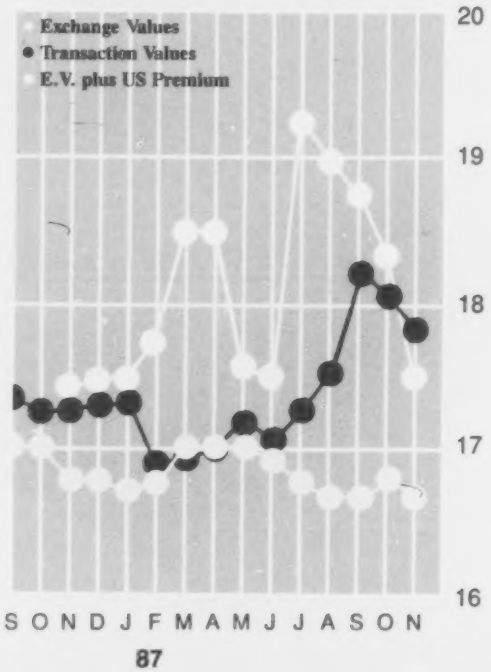

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EXECUTIVE SUMMARY
REPORT 232
(All data as of November 30, 1987)

Exchange Value $16.65, down $0.10

The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month. The US Premium (relative to the Exchange Value) is $0.85, down $0.80 since last month.

UF_6 Value $47.00, unchanged

The **UF_6 Value** is **$47.00** per kilogram U as UF_6, unchanged since last month. The US Premium (relative to the UF_6 Value) is $2.25, down $0.85 since last month.

Transactions

Eight recent natural uranium sales are reported, involving **1.8 million** pounds equivalent U_3O_8. Seven of the sales involved spot or near-term delivery, and five met the conditions for inclusion in the Transaction Value. In addition, one sale of low-enriched uranium is reported. Active spot and near-term **uranium supply** amounts to **6.8 million** pounds U_3O_8 equivalent, up 1.1 million pounds since last month. Active spot and near-term **uranium demand** totals **1.3 million** pounds, down 790 thousand pounds from last month. The spot and near-term **supply-demand ratio** increased to **5.4 to 1**.

Transaction Value $17.80, down $0.25

The **Transaction Value** is **$17.80** per pound U_3O_8, **down $0.25** since last month. The calculation includes transactions involving a total of 3.3 million pounds U_3O_8 and equivalent UF_6, of which 1.8 million pounds are US-origin, and covers a period of 3 months.

Loan Rate 3.5%, down 0.5%

The **Loan Rate** is **3.5 percent** per annum, down 0.5%. No loan transactions are reported.

Conversion Value $1.90, unchanged

The **Conversion Value** is **$1.90** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 550 thousand pounds U as UF_6. Active demand totals 220 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

SWU Value for delivery within one year: $73, up $4.00

The **SWU Value** at .3% tails assay and for delivery within one year is **$73** per SWU, up $4.00 since last month. Four secondary market SWU transactions are reported.

* * *

China

The People's Republic of China has an active, growing nuclear industry, with three reactors currently under construction and several more in the planning stage. China has established nuclear cooperation agreements with many countries, and its trade in nuclear-related goods and services is growing. This article examines China's historical nuclear planning, links with other countries, and its reactor construction program.

FASB

The Financial Accounting Standards Board (FASB) has recently issued several "Statements of Financial Accounting Standards" that further define and clarify how utility accounting procedures should deal with plant disallowances, abandonments and phase-in plans.

Italy

In a referendum held November 8, 1987, Italian voters have overturned three current laws that deal with government authority to override local opposition to power plant siting, financial incentives that may be offered to localities willing to host a power plant, and the participation of Italy's state utility ENEL in international nuclear projects, such as the Superphenix fast breeder reactor in France.

Raw Materials

Radiometric sorting of uranium ores offers certain production cost advantages to those producers able to use this technology. This article discusses how this technique may be applied and outlines radiometric sorting equipment in use at several sites around the world.

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NUEXCO REPORT 232 FIGURES OF THE MONTH (November 30, 1987)	This Month (Report 232)	Last Month (Report 231)	12 Months Ago (Report 220)
Exchange Value ($US per pound U_3O_8)	16.65	16.75	16.75
US Premium for the Exchange Value ($US per pound U_3O_8)	0.85	1.65	0.65
UF_6 Value ($US per kilogram U as UF_6)	47.00	47.00	48.00
US Premium for the UF_6 Value ($US per kgU as UF_6)	2.25	3.10	2.50
Transaction Value ($US per pound U_3O_8 equivalent)	17.80	18.05	17.30
Loan Rate (Per Annum)	3.5%	4%	4%
Conversion Value ($US per pound U as UF_6)	1.90	1.90	1.80
Near-Term Uranium Supply[1] (millions of pounds U_3O_8)	6.8	5.7	4.5
Near-Term Uranium Demand[2] (millions of pounds U_3O_8)	1.3	2.0	0.8
Near-Term Supply-Demand Ratio	5.4	2.9	5.9
Recent Uranium Sales:[3]			
Number of Transactions	9	13	6
Quantity of Material (Millions of pounds U_3O_8 equivalent)	1.8	9.4	0.8
Nuexco SWU Value: ($US per SWU)[9]			
at 0.3 tails assay	73	69	80
US DOE SWU Prices: ($US per SWU)			
USEC	117.00[4]	119.00[5]	119.00[6]
AFC	153.00	153.00[7]	153.00[7]
Requirements	157.00	157.00[7]	157.00[7]
Incentive Price	90.00[8]	90.00[8]	90.00[8]
Market Value of Enriched UF_6[8]: ($US per kgU as UF_6)			
2.5 w/o U_{235}	441	432	459
3.0 w/o U_{235}	563	551	588
3.5 w/o U_{235}	688	673	719
4.0 w/o U_{235}	814	796	852

[1]Active inquiries to sell, for delivery within 12 months after contract signing.

[2]Active inquiries to purchase, for delivery within 12 months after contract signing.

[3]Uranium sales only; does not include loans, conversion, or SWU transactions.

[4]Effective since 10/1/87.

[5]Effective since 10/1/86.

[6]Effective since 10/1/85.

[7]Effective since 10/1/84.

[8]Effective since 10/1/86, for up to 30% of annual requirements.

[9]Calculated using the Nuexco Exchange Value, Conversion Value, SWU Value and 0.30 percent tails assay.

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

December 1987 No. 232

R. GENE CLARK, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

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November 30, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.65**/lb. U_3O_8	6,845	1,275
US Premium	**$0.85**		
UF_6 VALUE	**$47.00**/kgU		
US Premium	**$2.25**		
CONVERSION VALUE	**$1.90**/lb. U as UF_6	550	220
SWU VALUE			
0.3 tails assay:	**$73**/SWU	500	25
LOAN RATE	**3.5%**/annum	5,100	0

TRANSACTION VALUE

$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
17.80	**3.3**	**18**	**3**

[1]Supply and demand tables in the *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

7. **The US Premium** is Nuexco's judgment of the incremental price (relative to the Exchange Value or UF_6 Value, as applicable) at which transactions for significant quantities of natural uranium could be concluded as of the date indicated, if the buyer will accept only US-origin.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed awillingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of prices, Nuexco does not consider transportation charges other than those customarily provided by suppliers .
4. The prices of services or materialss delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

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NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of November 30, 1987)

The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month. US-origin uranium is commanding a **premium** (relative to the Exchange Value) of **$0.85** per pound U_3O_8 (down $0.80) in the form of concentrates, and $2.25 per kilogram U (down $0.85) in the form of UF_6. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **6,845,000** pounds U_3O_8 equivalent, up 1.1 million pounds since last month. The corresponding figure for **active demand** is **1,275,000** pounds, down 790,000 pounds. The spot and near-term supply-demand ratio increased to 5.4 to 1.

The *Current Market Data* section of this Report lists six U_3O_8 sales, totaling 1.1 million pounds U_3O_8 equivalent.

The **Transaction Value** is **$17.80** per pound U_3O_8, down $0.25 since last month. The calculation extends over a 3-month period and includes 18 transactions involving 3.3 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.00** per kilogram U in UF_6, unchanged since last month. Three transactions involving UF_6 are reported, totaling approximately 700,000 pounds equivalent U_3O_8.

The **Conversion Value** is **$1.90** per pound U as UF_6, unchanged since last month. Active supply of secondary market conversion services totals 550 thousand pounds U as UF_6. Active demand totals 220 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

The **Loan Rate** is **3.5 percent** per annum, down 0.5 percent since last month. No loan transactions are reported.

* * *

The Exchange Value declined $0.10 to $16.65 per pound U_3O_8 this month, as the supply of material available on the market increased substantially and demand for concentrates declined. Sellers of non-US-origin uranium have been offering their material at prices around the Exchange Value level for the few available market opportunities. Overall, there has been little activity in the market for non-US-origin U_3O_8, and only one transaction is reported.

The Premium (relative to the Exchange Value) for US-origin U_3O_8 declined $0.80, to $0.85 per pound. Because of the uncertainties presented by the US Producers vs. DOE lawsuit and the proposed US-Canada Free Trade Agreement (FTA), a number of potential US buyers have decided, at least for the present, to await further developments before committing to procurement decisions. Demand for US-origin uranium remains at relatively low levels, and many buyers are currently unwilling to pay any premium for US-origin material. On the other hand, supply of US-origin U_3O_8 is plentiful and suppliers are competing aggressively for available US-origin opportunities.

This competition can be partly attributed to US producers' year-end cash flow requirements. Some US producers also feel that, because of the FTA, the prospects for a higher US premium and/or a restricted market in the USA are poor, prompting increased aggressiveness to move material at lower price levels.

As of the end of the month, two buyers reportedly were close to concluding transactions for US-origin material. One other US buyer is in the spot market for a significant quantity of US-origin material. Although one non-US utility is seeking a large quantity of US-origin material for extended delivery, that buyer's demand is discretionary with regard to both quantity and timing.

The *Current Market Data* Section of the Report shows five spot or near-term U_3O_8 transactions, involving approximately one million pounds. In addition, one long-term transaction is listed, between a US producer and a US utility, involving slightly less than one million pounds of US-origin U_3O_8. Five of the six U_3O_8 transactions reported this month invoived US-origin material.

The UF_6 Value remained unchanged at $47.00 per kgU as UF_6. Overall, the market for UF_6 has changed little since last month, showing weak demand for UF_6 of any origin. The Premium (relative to the UF_6 Value) for US-origin UF_6 declined $0.85 to $2.25. This decline was relatively less than that of U_3O_8 due to the smaller available supply of US-origin UF_6, compared to US-origin U_3O_8, and to the generally less active market. Three UF_6 transactions are reported this month, all of non-US origin, involving approximately 650,000 pounds U_3O_8 equivalent, including one sale of low-enriched uranium.

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The Loan Rate declined slightly, to 3.5 percent per annum, reflecting a sharp increase in the supply of material available for loan. Although there appears to be little or no active demand for loans, there are indications that large quantities of material, of almost any origin desired, could be made available for loans, provided that lenders' requirements for security can be met. The supply of material available for loan has increased significantly, as has the aggressiveness of potential lenders. No loan transactions are reported this month.

* * *

The Conversion Value remained unchanged this month at $1.90 per pound U as UF_6. The secondary market for conversion services remains largely inactive, with little or no available supply of bargain-priced conversion. Demand for conversion remains weak. No conversion transactions are reported.

ENRICHED URANIUM AND SWU

The SWU Value is $73 per SWU, up $4.00 since last month. The secondary SWU market is relatively quiet, with little active demand and a wide range of SWU prices based on origin, location and various risk factors to buyers. The increase in SWU Value represents the lessening in importance of highly discounted non-western SWU in the US market, since almost no buyers presently in the market are willing to take such SWU. (One of last month's potential buyers of non-western SWU concluded a transaction for DOE-origin enrichment at near the SWU Value, instead of taking the non-western enrichment that was offered.) Four SWU transactions are reported, totaling approximately 100,000 SWU. Two of these transactions involved the purchase of enriched uranium product.

THE US-CANADA FREE TRADE AGREEMENT

Negotiations over the FTA's final language are reported to be close to completion. However, there remain many unanswered questions and criticisms regarding the Agreement, and its passage in either the US Congress or the Canadian Parliament is far from certain.

In November 1987, House Energy and Commerce Committee Chairman John Dingell (D-Michigan) sent a letter to the Reagan Administration that included more than 40 detailed questions about the FTA. This letter noted that several Congressional Committees could want to amend the FTA in ways that would satisfy the objections of some affected industries, including oil, pharmaceuticals, uranium, automobiles, and others.

According to an internal memorandum from the US Trade Representative's office, the fast-track procedure for Congressional approval and implementation of the FTA may, in fact, be rather easily changed by Congress. Such a change would be necessary if Congress insists on amending the FTA as it currently exists.

> "At any time the House Rules Committee could recommend and report a change in the rules to the House floor. Adoption of such a resolution requires only a majority vote ... Likewise in the Senate, normally the Senate Rules Committee would review and report a resolution to change the rules. Adoption of such a rule change normally requires a majority vote. The Rules Committee may be bypassed entirely and a rule change adopted on the Senate floor if unanimous consent were obtained (but even a single objection would block unanimous consent)."

The memo also notes that:

> "January 2, 1988 is the only day the President can enter into the Agreement. If he signed any earlier, he would not be in compliance with the 90-day notice requirements of section 102(e)(1) of the Trade Act of 1974, as amended. If he signed any later, the authority under section 102 for such agreements would have expired (unless extended in the interim by legislation)."
>
> "As a matter of law, we believe that there is no deadline for submission by the President to

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the House and Senate of the Agreement, implementing legislation and required statements.

"As a *political* rather than legal matter, Bob Dove of Senator Dole's office (and the former Senate parliamentarian) believes that many Members believe that eligibility for fast track consideration requires submission of the implementing legislation on January 2, 1988. The only possible legal basis for this view is Section 151(c)(1), which refers to the "day on which a trade agreement is submitted (to the Congress) . . . *under section 102*" (emphasis added), authority under which expires at midnight on January 2, 1988. However, the prevailing legal view is that trade agreements entered into under section 102 prior to its expiration are eligible for Congressional fast track review any time thereafter."

— Correction —

On Page 25 of last month's Report, we erroneously reported Mr. Peter Bradfield as representing CRA. In fact, Mr. Bradfield represents Energy Resources of Australia (ERA). We regret the error and any inconvenience it may have caused.

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CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Nov 30, 1987)	Last Month (Oct 31, 1987)	12 Months Ago (Nov 30, 1986)	This Month (Nov 30, 1987)	Last Month (Oct 31, 1987)	12 Months Ago (Nov 30, 1986)
Australia (dollar)	24.02	24.98	25.85	62.43	64.95	67.20
Belgium (comm. franc)	580.34	608.43	694.16	1,509	1,582	1,805
Canada (dollar)	21.80	22.07	23.22	56.69	57.39	60.36
EEC (ecu)	13.47	14.04	16.16	35.02	36.50	42.02
Finland (markka)	68.01	71.34	82.31	176.82	185.46	213.99
France (franc)	94.33	98.01	108.98	245.25	254.81	283.32
FRG (mark)	27.82	29.03	33.27	72.34	75.47	86.50
Italy (lira)	20,462	21,006	23,116	53,197	54,610	60,097
Japan (yen)	2,245	2,318	2,715	5,837	6,027	7,059
Netherlands (guilder)	31.30	32.69	37.86	81.38	84.98	98.43
South Africa (rand)	32.84	33.53	37.64	85.38	87.18	97.86
Spain (peseta)	1,866	1,952	2,254	4,852	5,075	5,859
Sweden (krona)	100.30	103.97	115.68	260.76	270.31	300.73
Switzerland (franc)	22.84	24.04	27.69	59.39	62.50	71.98
UK (pound)	9.28	9.76	11.75	24.13	25.37	30.55
US (dollar)	16.65	16.75	16.75	43.29	43.55	43.55

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Nov 30, 1987)	Last Month (Oct 31, 1987)	12 Months Ago (Nov 30, 1986)	This Month (Nov 30, 1987)	Last Month (Oct 31, 1987)	12 Months Ago (Nov 30, 1986)
Australia (dollar)	25.62	26.92	26.70	66.75	69.99	69.41
Belgium (comm. franc)	620.43	655.65	706.95	1,613	1,705	1,864
Canada (dollar)	23.31	23.79	23.98	60.60	61.84	62.34
EEC (ecu)	14.40	15.13	16.69	37.44	39.33	43.40
Finland (markka)	72.71	76.87	85.01	189.04	199.85	221.01
France (franc)	100.85	405.62	112.56	262.19	274.58	292.62
FRG (mark)	29.75	31.28	34.37	77.33	81.33	89.34
Italy (lira)	21,875	22,636	23,875	56,871	58,849	62,070
Japan (yen)	2,400	2,498	2,804	6,240	6,495	7,291
Netherlands (guilder)	33.46	35.23	39.10	87.00	91.58	101.66
South Africa (rand)	35.11	36.14	38.88	91.27	93.95	101.07
Spain (peseta)	1,995	2,104	2,328	5,187	5,469	6,052
Sweden (krona)	107.23	112.04	119.48	278.77	291.28	310.61
Switzerland (franc)	24.42	25.91	28.60	63.49	67.35	74.34
UK (pound)	9.92	10.52	12.14	25.80	27.34	31.55
US (dollar)	17.80	18.05	17.30	46.28	46.93	44.98

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on November 27, 1987.

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CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (Nov 30, 1987)	Last Month (Oct 31, 1987)	12 Months Ago (Nov 30, 1986)	This Month (Nov 30, 1987)	Last Month (Oct 31, 1987)	12 Months Ago (Nov 30, 1986)
Australia (dollar)	2.74	2.83	2.78	6.04	6.25	6.12
Belgium (comm. franc)	66.23	69.02	74.60	146.00	152.15	164.46
Canada (dollar)	2.49	2.50	2.49	5.49	5.52	5.50
EEC (ecu)	1.54	1.59	1.74	3.39	3.51	3.83
Finland (markka)	7.76	8.09	8.85	17.11	8.75	19.50
France (franc)	10.76	11.12	11.71	23.73	12.40	25.82
FRG (mark)	3.18	3.29	3.58	7.00	7.26	7.8[illegible]
Italy (lira)	2,335	2,383	2,48[illegible]	-5,148	5,253	5,477
Japan (yen)	256.20	262.98	291.78	564.83	579.76	643.27
Netherlands (guilder)	3.57	3.71	4.07	7.88	8.17	8.97
South Africa (rand)	3.75	3.80	4.04	8.26	8.39	8.92
Spain (peseta)	212.98	221.45	242.20	469.54	488.20	533.95
Sweden (krona)	11.45	11.79	12.43	25.23	26.00	27.41
Switzerland (franc)	2.61	2.73	2.98	5.75	6.01	6.56
UK (pound)	1.06	1.11	1.26	2.34	2.44	2.78
US (dollar)	1.90	1.90	1.80	4.19	4.19	3.97

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU Value at 0.30% tails assay (Nov 30, 1987)	UF_6 Value per kg.U in UF_6 This Month (Nov 30, 1987)	UF_6 Value per kg.U in UF_6 Last Month (Oct 31, 1987)
Australia (dollar)	105.29	67.79	70.09
Belgium (comm. franc)	2,544	1,638	1,707
Canada (dollar)	95.60	61.55	61.93
EEC (ecu)	59.06	38.02	39.39
Finland (markka)	298.20	191.99	200.17
France (franc)	413.60	266.28	275.01
FRG (mark)	121.99	78.54	81.45
Italy (lira)	89,714	57,761	58,942
Japan (yen)	9,844	6,338	6,505
Netherlands (guilder)	137.24	88.36	91.72
South Africa (rand)	143.98	92.70	94.09
Spain (peseta)	8,183	5,268	5,478
Sweden (krona)	439.76	283.13	291.74
Switzerland (franc)	100.15	64.48	67.46
UK (pound)	40.70	26.20	27.38
US (dollar)	73.00	47.00	47.00

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on November 27, 1987.

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CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Exchange or UF_6 Value[2]	Seller	Buyer	Remarks
4193	1989-1992	601-1,000	R[3]	Producer	Utility	US-Origin
4196	1988	301-600	108-112	Producer	Intermediary	UF_6
4198	1988	50-100	103-107	Producer	Utility	US-Origin
4199	1988	50-100	103-107	Producer	Utility	US-Origin
4210	1988	less than 50	98-102	Producer	Intermediary	US-origin
4211	1988	50-100	98-102	Intermediary	Utility	US-Origin
4212	1988	101-300	108-112	Producer	Intermediary	UF_6
4213	1988	50-100	98-102	Producer	Intermediary	
4214A	1988	50-100	98-102	Intermediary	Utility	Contained in low-enriched uranium

Enrichment Services Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[4] (thousands of SWU)	Approximate Price Range as Percent of Current SWU Value[5]	Seller	Buyer	SWU Origin	Remarks
4203	1988	50-100	98-102	R[3]	Utility		
4207	1988	less than 50	R[3]	Intermediary	Fabricator		Contained in high-enriched uranium
4214B	1988	less than 50	98-102	Intermediary	Utility		Contained in low-enriched uranium
4215	1988	less than 50	98-102	Utility	Utility	DOE	

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2] Where US-origin material is involved, the range is based on the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value). The range reflects five percentage points (inclusive) per grouping, centered about the middle of the range.
[3]The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client or source confidentiality.
[4]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[5]Prices are usually normalized to 0.30% tails assay. Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts from a reference price (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted prices, not on the reference price.

URANIUM SUPPLY
(November 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
	—		
Available for Sale:			
ACTIVE			
87-1002	270	—	
87-1023*	750	500 per year	1987-90
87-1053	100	400 per year	1989 on
87-1055	200	300 per year	1988-93
87-1061*	200	200 per year	UF_6, 1988 on
87-1091	1,000	1,000 per year	UF_6
87-1120	1,000	—	
87-1123	400	—	
87-1124*	1,000	500 per year	1988 on
87-1130	750	—	
87-1142	150	—	
87-1152*	200	—	
87-1156*	825	—	
87-1001	—	400 per year	1989 on
87-1005	—	400 per year	1988-95
TOTAL:	6,845		
INACTIVE			
87-1017	1,000	—	
87-1059	120	—	UF_6
87-1130	850	—	UF_6
87-1135	500	—	
87-1019	—	600 per year	1988-91
TOTAL:	2,470		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 1014A, 1022, 1025,1097, 1109.

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CURRENT MARKET DATA

URANIUM DEMAND
(November 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near -term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase: ACTIVE			
87-1030	175	—	
87-1121	650	650 per year	1988-96
87-1124*	75	—	UF_6
87-1138	175	—	UF_6
87-1140	200	—	
87-1013	—	1,200 per year	1990-95
87-1021	—	200 per year	1992 on
87-1107*	—	1,225	1990-92
87-1108	—	200 per year	1991-2000
87-1134	—	260	1989
87-1150*	—	1,000 per year	1989-92
TOTAL:	1,275		
INACTIVE			
87-1040	300	300	1989
87-1049	—	700 per year	1989-96
87-1114	525	—	
87-1125	390	—	
87-1146*	25	—	
TOTAL:	1,240		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 1007,1047, 1048, 1073.

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LOAN SUPPLY AND DEMAND
(November 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
87-1064	600	—	
87-1119	500	—	
87-1157*	4,000	—	
TOTAL:	5,100		
INACTIVE			
87-1012	2,000	—	
87-1031	1,000	—	
87-1033	1,000	—	
87-1071	1,000	—	UF_6
TOTAL:	5,000		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

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CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(November 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale:			
ACTIVE			
87-1155*	550	—	
TOTAL:	550		
INACTIVE			
87-1008	750	750	
87-1122	330	—	
TOTAL:	1,080		
Inquiries to Purchase:			
ACTIVE			
87-1132	220	—	
TOTAL:	220		
INACTIVE			
87-1009	220	—	
87-1072*	440	—	
TOTAL:	660		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

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SWU SUPPLY AND DEMAND
November 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWU) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
87-1058*	100	—	1987
87-1068	100	—	1988
87-1096	300	—	1988
TOTAL:	500		
INACTIVE			
87-1004	55	—	1987
87-1059	25	—	1987
87-1128	300	—	1987
87-1130	150	—	1989
TOTAL:	530		
Inquiries to Purchase:			
ACTIVE			
87-1154*	25	—	1988
TOTAL:	25		
INACTIVE			
87-1065	150	—	1988
87-1116*	100	—	1989
TOTAL:	250		

*New or revised since last month.
[1]Measured from the date of this Report.
[2] For delivery within one year. This category excludes SWU deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 1100.

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CHINA'S NUCLEAR POWER PROGRAM

Introduction

The People's Republic of China has, since the 1950s, built a fairly extensive nuclear industry, incorporating a military reactor program, a number of research reactors and fuel-cycle facilities, and development of domestic uranium resources. The Institute of Atomic Energy in Beijing operates a 10-MWth research reactor, a 3.5 MWe pool-type reactor and a 12-MWe heavy water reactor, upgraded from its original 7 MWe. Shanghai's Atomic Energy Research Institute, which conducts research into reactor design, in 1984 commissioned a 27-MWe PWR. Currently, a 5-MWth water-heating reactor is being built by the Institute of Nuclear Technology at Qinghua University, combining technologies from the FRG and the USSR. In 1980, the Southwest Institute of Reactor Design Engineering at Jiajiang, in Sichuan province, commissioned China's largest research reactor, a 125-MWe high-flux unit. Shortly after this unit began operating, Premier Li Peng noted that it was the tenth indigenous research reactor to be commissioned in China.

China currently has three commercial PWRs under construction — a twin-unit (2 x 960-MWe) station at Daya Bay near Hong Kong and Guangzhou, and a single 300-MWe unit at Qinshan, near Shanghai. The Daya Bay station is being built by a consortium headed by Framatome and Electricite de France (EdF) and is based on current French PWR technology. The plant at Qinshan is a domestic design, built mainly with Chinese-manufactured equipment.

China's International Nuclear Agreements

In nuclear technology and trade, China's relationships with other countries gradually have extended to the point where relatively normal commerce is able to take place. China has entered into bilateral nuclear cooperation agreements with many countries, including Argentina, Belgium, Brazil, the Federal Republic of Germany, Finland, France, Italy, Japan, Pakistan, Switzerland, the United Kingdom and the USA.

China's bilateral cooperation agreements with other countries provide a vital link for contacts between Chinese personnel from any of several organizations, and persons from the other country, who might work for the government, or for research organizations, trade entities, or private companies. Exchanges of technical information and personnel, as well as equipment sales, often are organized through channels opened by these cooperation agreements.

On January 1, 1984, China joined the International Atomic Energy Agency (IAEA) and stated that it would voluntarily adhere to IAEA safeguards conventions. However, as is the case with France, the PRC remains outside the Non-Proliferation Treaty (NPT) structure. After lengthy discussions with the IAEA, China offered to let that organization conduct inspections of certain civilian nuclear facilities, in much the same way as do the other "nuclear weapons states."

Argentina — In 1985, Chinese Vice Minister Lin Zhongtang visited Argentina, touring several engineering and supplier companies. Later, the two countries signed a cooperation agreement covering research, design, construction and operation of turbine generators, uranium mining, conversion, and fuel fabrication. Argentina's development of heavy water production facilities, enrichment and reprocessing reportedly also were topics of discussion. Two shipments of heavy water have been bought by Argentina from China, but to date, no contracts between Chinese and Argentine equipment suppliers are known to have been finalized.

Brazil — A cooperative agreement was signed in 1985 between China and Brazil. Brazil's nuclear industry, which offers a number of services and products, hoped that the cooperation agreement would lead to increased trade, but no activity has been reported between China and Brazilian nuclear-industry companies.

Canada — In 1984, representatives of the Chinese Nuclear Society signed a technical exchange agreement with the Canadian Nuclear Society, as well as touring a number of Canadian facilities. For some time, China has imported most of its gamma-ray (Cobalt-60) radiation sources for medical and industrial uses from Canada.

Finland — In July 1987, the governments of China and Finland signed a nuclear cooperation agreement that would promote closer ties between the two countries. The agreement came in conjunction with a long-term uranium sale by China to TVO (Teollisuuden Voima Oy), a Finnish utility, to supply 600 MT of uranium between 1988 and 1995, about 30 percent of TVO's requirements in that period.

France — Chinese-French nuclear cooperation began with the signing of an agreement in 1975, and France's

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involvement in China's nuclear industry is perhaps the most extensive of any foreign country. The twin reactor complex at Daya Bay, near Guangzhou, is being supplied largely by French manufacturers, chiefly Framatome. China also has sold uranium to the French utility Electricite de France (EdF).

Federal Republic of Germany — Companies from the Federal Republic of Germany (FRG) also have a long-standing relationship with China's nuclear industry, and have been involved in nuclear-related business ventures or proposals in several areas, including supplying reactors, aiding in uranium exploration, and buying Chinese uranium. For some time, many observers believed that Kraftwerk Union (KWU) would get the order to supply twin 900-MWe reactors for the proposed Sunan site, near Shanghai. A number of German companies had interests in this venture, which included various countertrade possibilities designed to offset much of the hard currency required to build the plants as a turnkey project. The negotiations also included the possibility of China's disposing of or storing some German spent reactor fuel at a site to be chosen in the Gobi desert. However, when the Chinese leadership decided in favor of greater domestic development of nuclear technologies, the Sunan project was "indefinitely postponed," at least as a turnkey job.

KWU continues to maintain a presence in China, however, and is actively participating in a feasibility study to determine what type and size, if any, may be appropriate for additional units to be added to the Qinshan site. In August 1987, Chancellor Helmut Kohl visited China, and while no formal agreement was signed, the visit prompted the Chinese government to state officially its intention to continue the two countries' ongoing bilateral cooperation. This cooperation has largely been carried out under the auspices of Kraftwerk Union.

Japan - China's first preliminary understanding on nuclear cooperation with Japan was reached in March 1984, and was the precursor to a formal commercial relationship in nuclear trade between the two countries. In May 1986, Japan's Diet finally approved the official nuclear cooperation agreement with China that had been signed in mid-1985 by representatives of the two countries. The agreement calls for cooperation in reactor design and construction, nuclear waste disposal technology, and research and information exchanges. As early as 1982, Japan's Power Reactor and Nuclear Fuel Development Company (PNC) began buying small amounts of uranium from China, delivered in several shipments through 1985. These purchases represented China's earliest commercial sales of uranium abroad, and demonstrated that the Chinese could supply U_3O_8 of acceptable purity, and on a timely schedule. Japanese organizations also are involved in joint uranium exploration or production feasibility studies in China, and are supplying various types of equipment and services to the Qinshan and Daya Bay projects.

Switzerland - In November 1986, the government of Switzerland signed a bilateral nuclear cooperation agreement, followed in May 1987 by the Swiss Federal Executive Council's recommendation that Parliament ratify the agreement. Under the proposed pact, Swiss utilities will be able to buy uranium directly from China, and Swiss industry can more easily supply services, equipment, and technology to China. The accord also lets Switzerland pursue the possibility of sending spent fuel and vitrified high-level waste to China for storage, reprocessing or permanent disposal.

USA — An agreement was first signed in July 1985 between the USA and the PRC, and on December 31, 1985, a 30-year US-China nuclear cooperation agreement took effect, after an exchange of notes by US and Chinese government officials in Beijing. Under the agreement, the State Department gave the NRC authorization to proceed with issuance of all pending licenses for transfer of nuclear-related technology to China.

Following the signing of the initial agreement, but before its approval by Congress, a number of export licenses had been authorized. Several pending applications, however, had been held back, such as one allowing Mitsubishi Heavy Industries Ltd. to ship the completed reactor pressure vessel, which it built under license from Westinghouse, to the Qinshan project. Since the signing of the agreement, American companies and their non-US licensees have been much more free to pursue sales of equipment or licensing arrangements with the Chinese. The signing of the agreement took place just before China's decision to cut back on purchasing of foreign materials and on foreign involvement, generally, in China's nuclear power development program.

The full text of the arrangements finally was negotiated in June 1987, and has since been undergoing interagency review. Finalization requires that President Reagan certify to Congress that the arrangements of the cooperation agreement will ensure that exports of US equipment are used for peaceful purposes. Before any exports can be licensed, the certification must be before Congress for 30 days of continuous session.

United Kingdom — China also has a long-standing

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relationship with the UK in nuclear commerce, and the UK's General Electric Company (GEC) is one of the suppliers for the Daya Bay project. Much of the early negotiation over the Daya Bay project concerned the participation in the venture of the Hong Kong Utility, China Light and Power, and the involvement of the British government in securing a portion of the Daya Bay business for companies in the UK. Financing for the project was partially handled by a consortium of ten British banks, led by the Midlands Bank. In addition, the Chinese and British governments have had considerable interaction over the status of the UK's relinquishing of Hong Kong to the Chinese in 1997.

China's Nuclear Planning

During the past five years, China's commercial nuclear development plans have undergone considerable change. Originally, these plans called for installation of 10,000 MWe of nuclear generating capacity by the year 2000, and international reactor manufacturers had high hopes of a large export market to China.

By 1985, ongoing negotiations with foreign suppliers for twin-unit nuclear projects at Daya Bay, near Hong Kong, and at Sunan, north of Shanghai, pointed to a near-term construction program of nearly 4,000 MWe that was open to bids from foreign suppliers. Other sites also were being investigated in Liaoning Province and at Jinshanwei, also near Shanghai. Completing the 10,000-MWe nuclear capacity called for in the plan would have meant building at least six other large reactors in addition to those planned for Daya Bay and Sunan.

The French companies Framatome and Electricite de France (EdF), in conjunction with the UK's GEC, took an early lead in the bidding for Daya Bay. In December 1985, the Chinese and the French and British companies involved in Daya Bay signed a memorandum of understanding, agreeing in principle to sign contracts for the Daya Bay project. Having such a memorandum indicated that most of the fine points of the negotiations had been settled, and cleared the way for a formal letter of intent to purchase. On March 12, 1986, letters of intent were signed with the principal suppliers for Daya Bay.

KWU, on the other hand, appeared to be in the best position to win the contract for the Sunan project; its interest was closely tied to countertrade possibilities that included accepting Chinese nonferrous metals and other materials as part payment, buying Chinese uranium, and possibly storing or disposing of some spent fuel from Germany in China. However, on March 3, 1986, within three months of the Daya Bay memorandum of understanding, Chinese officials announced that negotiations over the Sunan project were being indefinitely postponed, due to lack of available funds.

Then, in April 1986, after a visit with Premier Zhao Ziyang to the Qinshan reactor site, Deputy Prime Minister Li Peng surprised western suppliers by announcing that China's nuclear construction program would henceforth rely as greatly as possible on indigenous technology. Under the new policy, major foreign involvement would be limited to the Daya Bay project, at least as far as primary design and construction were concerned. Zhao stated that nuclear plants built in the near future would likely be based on technology similar to that used in the 300-MWe Qinshan design, uprated to the 600 or 900-MWe range. The nuclear energy plan was downgraded to 6,000 MWe nuclear capacity by 2000, from 10,000 MWe. Li reiterated the same sentiment in mid-1987, stating that nuclear power was not considered as a primary electric power source, but rather would be used only in certain places, and only as China could afford. The emphasis on hydropower and coal would continue unchanged.

One of the main reasons behind this shift in policy was concern over the economics of the Daya Bay project. From the beginning, financing the Daya Bay venture depended heavily on the financial participation of China Light & Power, thereby limiting the investment required of China. The Guangdong Nuclear Power Joint Venture Company (GNPJVC), which is the project owner, is a joint venture between Guangdong Nuclear Investment Company (75-percent) and China Light and Power (25-percent).

Even though much of the investment would be paid through electricity sales to Kowloon and the New Territories (Hong Kong Island is served by Hong Kong Electric, not a partner in the joint venture), Hong Kong's electricity consumption growth rate has been declining, especially in manufacturing-related demand. At the same time, joint-venture partner China Light & Power also shifted its position, saying that it intended to use its portion of Daya Bay's output for peak rather than base loads, and therefore could not guarantee to take as much of the plant's power as originally hoped.

The Daya Bay station's planned drain on hard currency reserves considerably influenced how scarce foreign exchange would be distributed throughout the rest of the

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nuclear program. There was no room in the budget for two foreign-supplied twin-unit power stations, and plans for Sunan were put aside.

Another problem for China's nuclear planners concerned the availability of materials. In order to assure that materials would be available to build these prospective nuclear plants, a high degree of priority would have to be given to their construction. Shortages of materials often have threatened China's large construction projects with delays, and have caused much competition among various bureaucracies attempting to ensure scheduling of their projects. The high government priority assigned to Qinshan, for example, has enabled that project's civil and mechanical construction to continue approximately on schedule, but has evoked heated criticism for its diversion of resources from other projects. Timely construction of a whole program of nuclear plants would require a masssive shift in construction priorities to the nuclear program. There is little assurance of a large nuclear program getting such attention.

There was a solid rationale for concentrating more resources on domestic production. Capital costs and loan costs of foreign-sourced nuclear plant construction are much higher than for those built in China. Even though building nuclear plants using domestic designs and fabrication as much as possible would limit technology transfer from the West and Japan, China has long felt the need to assert its independence in this area of high technology. One drawback at present is the limited capacity of existing electrical grids and limited regional interconnection. Of the more than 20 power grids in China, only four exceed 8,500 MWe in installed generating capacity, and most would be unable to accommodate nuclear plants of more than 200 MWe unless interconnected.

In July 1987, China and the FRG officially decided to continue with bilateral nuclear cooperation, during a visit to China by Chancellor Helmut Kohl. The decision had been helped by KWU's participation, even after the Chinese decision to pursue an indigenous-only program, in a joint feasibility study with China's Ministry of Nuclear Industry to explore ways to develop a 600-MWe reactor loosely based on the Qinshan design. The study showed that KWU's help in building a 600-MWe reactor could include an acceptable balance between Chinese and foreign involvement, while providing considerable technical assistance.

Accordingly, since Kohl's visit there have been some indications that the indigenous-only policy could be modified to once-again include foreign assistance for additional reactors at the Qinshan site. Although China has not actually committed itself, the key to the plan's success probably lies in the type of arrangements that can be made to pay for the foreign participation in the plants.

Negotiations, evidently carried out over a lengthy period of time and at a high political level between the Chinese and West German governments as well as representatives of KWU and several German utilities, have once again centered around a multi-faceted countertrade arrangement involving reactor design and equipment supply, purchases of Chinese uranium by German utilities, and possible storage or reprocessing in China of German utilities' spent fuel. This would likely include a high degree of Chinese manufacturing involvement in any reactor construction, considerable technology transfer to China, as well as competitive pricing of Chinese uranium.

Thus, although the role of KWU and the FRG in China's nuclear planning appears to be unofficial as yet, the current nuclear development plan, based on domestically-built reactors, appears to again be changing. The plan now aims to develop a domestic manufacturing base for the 300-MWe PWR design such as is found at Qinshan, with some outside design and manufacturing assistance in upgrading to 600-MWe. China clearly intends to eventually produce indigenously the types of equipment that currently are being imported for Qinshan, as soon as domestic facilities can attain the technical levels required; technology licensing will be preferred over out-of-country manufacture.

At present, Chinese energy plans appear to accept in principle the construction of up to four additional 600-MWe PWR units at the Qinshan site. The 300-MWe reactor under construction is now officially scheduled for trial operation in 1990, and probably will not start commercial operation before the early 1990s. The site will then be open for additional construction. However, it seems perhaps too ambitious for four more units to be completed at that site by 2000, and under the most optimistic scenario, China would not have more than 4,500 MWe of nuclear capacity, including Daya Bay, by the year 2000.

The current planning is generally consistent with China's industrial development philosophy as it has been implemented over the last thirty years. China has managed to avoid the large foreign debts that plague most less developed nations, and to the maximum degree possible has avoided turnkey development projects. This does not mean

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that foreign companies should abandon hope of participation in China's nuclear program. Components will continue to be imported as needed, and licensing arrangements as well as design services will be selectively sought.

Other Planning and Research

Although they are not likely to receive nuclear plants in the near future, at least two other sites also have undergone preliminary investigation — the Sunan site earlier planned for a turnkey reactor project that was canceled, and a site in Liaoning Province that has been mentioned but not as extensively investigated. A reactor complex at Sunan would serve the densely populated and highly industrialized Yangtze River delta region near Shanghai, Hangzhou, Souzhou, and other cities. Building on this site might have the added advantages of fairly rapidly increasing power capacity to the delta, while avoiding a bottleneck if more than one reactor at a time were underway at Qinshan.

It is possible that China will proceed with plans to build at least one, and possibly two medium-sized reactors for district heating. Two northern cities, Harbin and Shenyang, have included proposals for such reactors in their development plans. Qinghua University in Beijing has for some time been actively developing a 5-MWth prototype heating reactor, and reportedly is set to install such a unit 60 km northwest of Beijing, providing heating for 70,000 m^2 of building area. This reactor is a modified BWR, using 3-percent enriched uranium fuel, designed for a high degree of inherent safety. Cooling is by natural circulation, with three circuits. The middle, or secondary circuit carries higher pressure than either the primary or tertiary circuit (the one carrying heated water away from the plant), preventing leakage into the secondary circuit from either side.

Active research and planning is underway at Harbin, under the direction of the State Scientific and Technology Commission, to determine the requirements for building a 450-MWth, low-temperature district heating reactor. Such a unit would supply heat to a ten million m^2 building complex, saving 600,000 tons of coal per year, and also could possibly operate in conjunction with the Yilin coal gasification project at Harbin.

Chinese nuclear planners also have investigated the possibilities of using nuclear plants for co-generation, producing both electricity and process heat or steam for large industrial complexes. One of the sites mentioned in 1984 and 1985 was Jinshanwei, south of Shanghai near the Qinshan project. The government investigated the possibility of building twin 450-MWt reactors to supply power and steam to the Shanghai General Petrochemical Plant, which now burns oil to generate the 500 tons of steam needed per hour. Such a reactor plan would free some oil resources for local power generation, but would not contribute directly to the electricity grids. The petrochemical complex sits on very soft ground, and the Southwest Reactor Engineering Research and Design Institute in Sichuan has conducted detailed site planning and technical studies into design of the nuclear island.

Current Nuclear Projects

Qinshan — Plant 728, otherwise known as Qinshan, located 92 km from Hangzhou and 126 km southwest of Shanghai (Figure 1), had its start in 1972, when Premier Zhou Enlai first approved funds for its development. From the start, Qinshan has been a flagship project intended to demonstrate China's self-reliance in nuclear engineering. The original PWR design was based on experience gained in China's nuclear submarine program. At 300 MWe, the plant is the smallest of any current or planned commercial units and its size has left it vulnerable to criticism concerning cost-effectiveness, compared to coal-fired power plants. It remains a high-priority item under the current five-year plan, however, and has considerable visibility as a symbol of Chinese progress and self-reliance in high technology.

Civil construction began in March 1984, requiring removal of over one million cubic meters of rock and soil in order to begin construction of the main buildings. The civil engineering and construction is being carried out by the Nuclear Engineering Company, under the direction of the Ministry of Nuclear Industry. Construction of the main reactor buildings started in January 1985, and the 7.5 m-thick concrete foundation mat was completed by June. The civil works were basically completed by mid-1987.

Participation by foreign firms in the Qinshan project is expected to total from 20 to 30 percent of the $300-400 million total project cost. The reactor pressure vessel has been built by Mitsubishi Heavy Industries (Japan), KSB (FRG) is supplying the main coolant pumps, Sandvik (Sweden) is providing the steam generator tubing, Sulzer (Switzerland) will supply the steam isolation and turbine bypass valves, and Pirelli (Italy) will provide cables. In-core instrumentation is to be provided by Framatome, at a cost of about $1 to 1.5 million.

The project's 300-MWe turbine generator and moisture separator reheaters are being supplied by Shanghai Turbine

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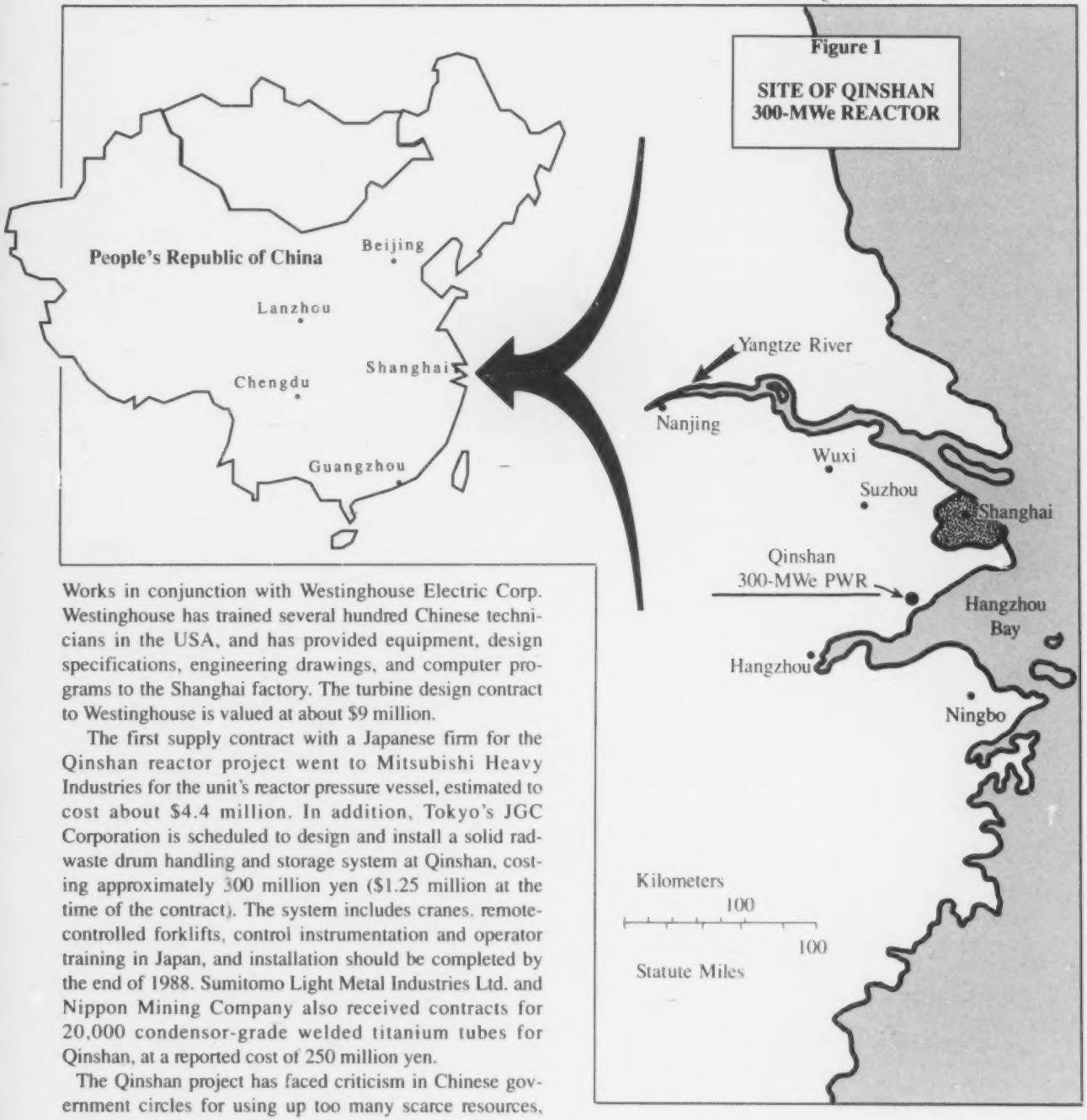
Figure 1

SITE OF QINSHAN 300-MWe REACTOR



Works in conjunction with Westinghouse Electric Corp. Westinghouse has trained several hundred Chinese technicians in the USA, and has provided equipment, design specifications, engineering drawings, and computer programs to the Shanghai factory. The turbine design contract to Westinghouse is valued at about $9 million.

The first supply contract with a Japanese firm for the Qinshan reactor project went to Mitsubishi Heavy Industries for the unit's reactor pressure vessel, estimated to cost about $4.4 million. In addition, Tokyo's JGC Corporation is scheduled to design and install a solid radwaste drum handling and storage system at Qinshan, costing approximately 300 million yen ($1.25 million at the time of the contract). The system includes cranes, remote-controlled forklifts, control instrumentation and operator training in Japan, and installation should be completed by the end of 1988. Sumitomo Light Metal Industries Ltd. and Nippon Mining Company also received contracts for 20,000 condensor-grade welded titanium tubes for Qinshan, at a reported cost of 250 million yen.

The Qinshan project has faced criticism in Chinese government circles for using up too many scarce resources, both material and financial. Scaling up the plant to 300 MWe from the original naval reactor design meant

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acknowledging that the Chinese nuclear industry was not yet able to produce some major components needed for large-scale commercial power reactors. Buying these components abroad required increasing the allocation of hard currency reserves for the project, and domestic costs also have approximately doubled from the original estimate. Justification for buying foreign-made parts has been made easier now that Qinshan officially is the prototype for a proposed indigenously-based nuclear construction program.

By mid-1987, over 70 percent of the internal reactor parts, and over 50 percent of all major components have reportedly been completed; the entire Qinshan project is said to be approximately two-thirds finished. Although the original official schedule called for completion by 1989, the schedule has now been extended to 1990. Western observers say that even that date may have to be pushed back, to perhaps 1991.

Daya Bay — For international reactor suppliers, one of the most desirable major nuclear plant orders of the 1980s involved the 2-unit PWR project at Daya Bay, near Guangzhou (Canton) and Hong Kong (Figure 2). Negotiations for the project started in 1979, and for a time, Daya Bay appeared to be the forerunner of a significant nuclear power program in China, in which foreign suppliers could have a major presence. Although those plans have been scaled back, the Daya Bay plants still were one of the few new nuclear plant construction projects available to international nuclear industry suppliers in the early and mid-1980s.

The owner of the twin-unit, 960-MWe PWR plant is Guangdong Nuclear Power Joint Venture Company (GNPJVC), which is a joint venture of China Light & Power Company of Hong Kong (25-percent) and Guangdong Nuclear Power Company (75-percent). Under the venture's agreement, the Hong Kong partner will have the option to take up to 70 percent of the units' electricity when the plants go into operation in the early to mid-1990s.

The first phase of site preparation began in April 1984, and was completed by July 1986. Primary civil construction started shortly after. The site requires construction of a nuclear island, ship docking facilities, an underground waterproof wall over one kilometer long, a reservoir, and a highway connecting the island to the city of Shenzhen, about 50 km away.

The protracted negotiations were formalized on September 23, 1986, when Framatome, Electricite de France and General Electric Company of the UK signed final contracts for the supply of engineering and equipment. Framatome's fixed-price contract covers construction management of the nuclear islands, supplying of the nuclear steam supply systems plus auxiliary systems and equipment, and the first two reactor cores for each unit. The contract is valued at approximately 6 billion French francs (about $980 million at current exchange rates). EdF is to act as architect-engineer and will also provide consulting services, in a contract valued at slightly over 1 billion francs. GEC Turbines Limited, a subsidiary of GEC, will supply two 900-MWe turbine generators valued at more than $350 million. The Daya Bay plants are based on the three-loop technology found in 34 French PWR plants, and EdF's Gravelines Units 5 and 6 are considered the reference units for the Chinese project.

EdF's contribution includes acting as consultant to the owner, GNPJVC, in various levels of project management. EdF is participating in negotiations concerning the civil contracting, as well as contracts for various equipment items that are not covered under the contracts to the main suppliers, Framatome and GEC. EdF's responsibilities also include overall engineering for the project, engineering studies for much of the station buildings, excluding the turbine building, and advising on operating procedures. The project management team, consisting of EdF and GNPJVC personnel, will be working both in Shenzhen and in France, and will oversee quality control on equipment manufactured inside and outside China.

Chinese personnel also will be trained in operating procedures both in China and in France. Operating personnel will train on simulators first, then will be assigned to a French PWR plant of a similar design for hands-on training. The Chinese State Nuclear Safety Administration reportedly has bought a second-hand three-loop Westinghouse PWR simulator from the USA, to be part of Qinghua University's Institute of Nuclear Energy Technology. The simulator will be installed in the Institute's new nuclear plant training center near Beijing. Chinese personnel are working to adapt the unit to simulate the new plant's operations.

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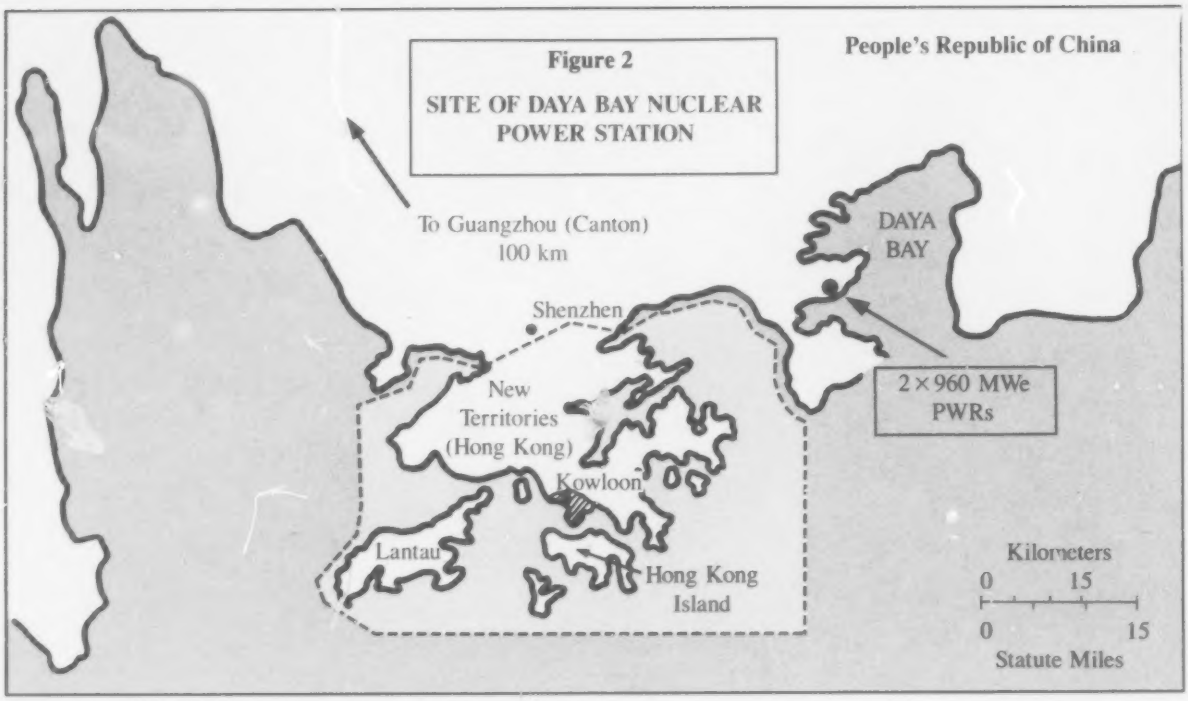

The primary civil construction is being performed by a joint-venture of several organizations. China's Huaxing Nuclear Industry Construction Company and the Second Bureau of China State Construction Engineering Company have been awarded contracts for 50 percent and 5 percent of the civil work, respectively. France's Campenon Bernard and Japan's Maeda Construction Company have 35 percent and 10 percent interests, respectively. Campenon Bernard is the technical leader for the nuclear island construction, while Maeda is technical leader for balance-of-plant construction. The civil engineering portion of the project is valued at about $224 million, and will include the reactor and fuel storage buildings, as well as other facilities at Daya Bay.

In other contracts with non-Chinese suppliers, 120 km of nuclear power transmission lines will be built by a Japanese-British consortium consisting of Sumitomo Electric Industries and Balfour Beatty Power Construction Ltd. of London. The 400 and 500-kv lines will provide power for Kowloon and the New Territories, and are expected to be completed by 1992. The contract is with China Light and Power and is reported to be worth 12 billion yen (US$ 83 million).

Bechtel North American Power Corp., with Bechtel China Inc., also has signed a contract to provide quality assurance consulting for the Daya Bay project. Bechtel will monitor quality assurance, both on-site in Guangdong, and at sites in Europe and China where various components are being built, as well as providing training for Chinese personnel.

The total cost of the Daya Bay project is estimated to be about $4.1 billion, of which the French share is about $1.3 billion, and the British share is about $350 million.

Conclusion

China's experience with nuclear power is substantial, but primarily involves plutonium production and research-type reactors. Overall, China has established an extensive network of bilateral cooperation agreements with many countries, including nearly all countries with significant nuclear industries. These agreements have increasingly brought China into the mainstream of international nuclear power developments, and nuclear-related trade with many countries has increased steadily over the past several years.

At present, two nuclear power stations are under construction -- a 300-MWe indigenously-designed PWR at Qinshan and the twin 960-MWe PWRs at Daya Bay, near

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Hong Kong. Prospects for foreign participation in China's nuclear program have changed considerably with policy swings involving debates on the most desirable mix of electric generating technologies, and with changing levels of China's foreign currency reserves.

It now appears that China will allow a limited amount of foreign assistance in its nuclear program, perhaps involving KWU's help with additional reactors for the Qinshan site in the mid-to-late 1990s, but that China intends to build a domestic nuclear industry to the maximum extent possible. Future sales to China by foreign firms may be closely tied to a considerable degree of technology transfer, as well as possibly including countertrade-type financial arrangements that would spare China the need to use its hard currency reserves for payment.

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ITALY

In a referendum held on November 8, 1987, Italian voters voted to overturn three laws, concerning nuclear plant siting, financial incentives to localities, and Italy's participation in international energy projects. The turnout for the referendum was lower than expected, only 62.5 percent of registered voters compared to 77.9 percent at a referendum two years ago, a figure that has been used by nuclear advocates to downplay the apparent further anti-nuclear shift in public opinion.

1. The existing law on power plant siting (not just nuclear plants) was overturned by a majority of 80.6 percent of the voters. This means that the central government will no longer be able to override local opposition to power plant sites.

2. The law appropriating funds to cities or towns that agree to accept plant sites was defeated by a 79.7-percent vote. Local authorities will no longer be offered financial incentives to accept plant sites in their areas.

3. A 71.9-percent majority overturned ENEL's (Ente Nazionale per l'Energia Elettrica — the Italian state utility organization and owner of Italy's commercial nuclear plants) right to participate in international nuclear projects, such as the Superphenix fast breeder reactor.

The referendum mandates that legislation be introduced within 120 days to repeal the three laws. However, the process of abrogating the laws and replacing them with new ones could take a considerable length of time to complete, during which ENEL may continue to operate on a business-as-usual basis.

The repeal of the three existing laws places severe constraints on any further nuclear development in Italy, and is likely to further curtail existing nuclear construction and development. Although at present, nuclear generated electricity only amounts to about 5-6 percent of generating capacity, additional nuclear development will be very difficult to achieve if needed. Since no alternatives were offered in the referendums, there is likely to be a period of considerable uncertainty, particularly with respect to how new power plant sites are to be chosen, and to the financial inducements, if any, that can be offered for new plant development.

The ruling Christian Democrat (CD) Party, at one time a strong supporter of nuclear power, recently has been embroiled in political problems unrelated to nuclear development, and so has been increasingly unwilling to challenge the anti-nuclear Green Party and the Socialists over nuclear-related issues. In fact, the CD Party recently announced that it would not advocate supporting nuclear energy in the upcoming referendum. In light of this policy reversal, the results of the referendum became nearly a foregone conclusion.

While the attitude of the public to future nuclear construction appears to have been demonstrated, the effect on existing plants is not so clear. Italy's three operating commercial reactors have been shut down since October 1986, at first for periodic refuelling and inspection and maintenance, and then because nuclear authorities have withheld approval to restart the units until the results of the referendum had clarified the plants' operating status.

For the near term, the Caorso (862-MWe BWR) and Trino-1 (270-MWe PWR) plants will likely go back into operation, but the Latina unit, a 210-MWe Magnox that entered service in 1963, probably will be closed and decommissioned. Two twin-unit nuclear stations are under construction in Italy — the Montalto di Castro station (2 x 1,000-MWe BWRs, scheduled for completion in about 1990) and the second station at Trino Vercellese (2 x 1,000-MWe PWRs in the early stages of construction). Their completion will depend on gaining approval from the Italian Parliament, an outcome that is far from certain. One plausible scenario could be completion of the Montalto di Castro units, but indefinite deferral or cancellation of the second station at Trino.

The referendum also has limited ENEL's authority to engage financially in international nuclear projects. However, one legal interpretation of the referendum is that it will be applicable only to future projects, and should not adversely affect projects already underway. At present, ENEL is a 33-percent shareholder in NERSA, the consortium owner of the 1,240-MWe Superphenix fast breeder reactor at Creys-Malville in France. Now that the Superphenix unit is operational, albeit with certain problems that have required the reactor to be shut down temporarily, ENEL's need to support the project financially is largely finished, and the utility can now reap some of its 400-MWe share of the plant's generating capacity. Since Italy must now import electricity from France anyway, withdrawing from NERSA would not help ENEL's cost outlook and could even hurt it. ENEL also is a 33-percent shareholder in ESK, a parallel consortium formed at the same time as NERSA to build a second large fast breeder plant in the FRG. As this project has not been started, it could be argued that the referendum's prohibition would be applicable to that project. In such a case, and since ENEL has not invested significant funds in ESK, it could presumably withdraw its commitment without great financial loss.

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ANALYSIS AND COMMENTARY

RECENT CHANGES IN UTILITY ACCOUNTING PROCEDURES — DISALLOWANCES, ABANDONMENTS AND PHASE-IN PLANS

Introduction

The Financial Accounting Standards Board (FASB), the private-sector panel that establishes policies for financial reporting, recently has issued revised standards for certain types of accounting procedures common to utilities that operate or are constructing nuclear units. These new standards will affect the manner in which utilities and public utility commissions view various events surrounding power plant construction, operation, rate-making, and capital recovery. The seven-member FASB panel consists of senior accountants appointed by trustees of the Financial Accounting Foundation. The panel issues "Statements of Financial Accounting Standards" which are accepted as authoritative accounting policy.

The events covered in two recent FASB statements, while relevant to all US utilities, are of particular interest to those utilities with nuclear programs. This is due to the inordinately large capital costs involved in building nuclear plants, as well as the increased scrutiny of public utility commissions in rate-making decisions for such utilities. In December 1986, FASB approved the issuance of a Statement that prescribes the proper accounting treatment for cost disallowances for recently completed plants and abandoned (canceled) plants. A Statement specifying the accounting treatment for cost "phase-in" plans for new units was released in August 1987. Both Statements were amendments of FASB Statement No. 71, entitled "Accounting for the Effects of Certain Types of Regulation", which was issued in 1982 and dealt with accounting treatment of various concepts for regulated utilities. Issues that had increased in importance in recent years warranted new analysis by the FASB, resulting in the amended rulings. Taken together, the new Statements will have important implications for those utilities involved in costly nuclear construction programs, as well as those experiencing cost disallowances in the course of PUC hearings.

Disallowances and Abandonment — Statement 90

FASB Statement 71, issued in December 1982, addressed various accounting treatments by utilities for their assets, plant construction, and rate-making, among other things. During and after the ruling, many utilities experienced cost disallowances and plant cancellations, most of which were nuclear plants. Shortly thereafter, the Board realized that these major events affecting the utility industry were not sufficiently discussed in Statement 71, and the Board decided to amend it to provide more specific guidance for the treatment of those events. In essence, the aim of the amendment was to clarify the accounting practices for those events so that a utility's financial reports most fairly represented its financial condition. Thus, Statement 90 was created to amend Statement 71 on the issues of plant abandonments, disallowances, and capitalization of allowance for funds used during construction (AFUDC). Statement 90 essentially requires that utilities write off the costs of canceled units and disallowed construction costs much faster than has been the practice.

When it becomes probable that an operating asset or an asset under construction will be abandoned, the cost of that asset shall be removed from construction work-in-process or plant-in-service. Any disallowance of all or part of the cost of the abandoned plant that is both probable and reasonably estimable shall be recognized as a loss. The present value of the future revenues expected to be provided to recover the allowable cost of that abandoned plant and return on investment, if any, shall be recorded as a separate new asset. Any excess of the remainder of the cost of the abandoned plant over that present value also shall be recognized as a loss.

Thus, utilities will be required to write off disallowed costs as a one-time charge against income, rather than as a decrease in income over the life of the plant, which has been the current practice. In this manner, any costs disallowed for recovery by the regulatory agency having jurisdiction would be recognized as an immediate loss on the utility's financial statements. The amount of the loss or write-off would equal the amount disallowed.

For abandoned plants, a similar treatment will be encouraged under the new standard. If a plant under construction is canceled, the utility will be required to report, on a present value basis, the probable future revenue that is expected to result if the cost of the plant is allowed in the ratemaking. A loss would be reported for the excess of the carrying value of the abandoned plant and the present value of the expected revenues from the plant. It is important to note that such revenues must be reported on a present-value basis to reflect the time value of money.

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Under the above scenario, a utility could list future revenues from an abandoned plant as an asset under two conditions:

1. The costs of the canceled plant were determined to be prudent and were allowed to be recovered in rates; and
2. The carrying costs of the canceled plant did not exceed the present value of such revenues.

However, this is not likely to be the case for most nuclear utilities. The extremely large capital costs of nuclear units, combined with the long construction times and regulatory delays, usually dictate that carrying costs of the canceled plant will exceed the present value of allowable costs. In those cases, reporting an immediate loss, or write-off, will be required.

In all of these cases, the reporting of the loss or present-value future revenue must be made as soon as the cancellation of the plant is probable, as defined in another FASB Statement. This has caused some controversy in the utility industry, in that utilities forced to report immediate write-offs for disallowances and canceled plants will be in effect reducing the company's assets. Any reduction of assets or value in the company, in the case of utilities, will lead to a reduction in book value and possibly the lowering of bond ratings and other financial indicators. Indirectly, write-offs can negatively affect a utility's ability to borrow funds or issue dividends on company stock.

Finally, Statement 90 specifies that allowances for funds used during construction (AFUDC) are to be capitalized (reported as an asset) only if it is probable that regulators will allow those costs to be recovered from ratepayers. Previously, Statement 71 required the capitalization of AFUDC in certain circumstances; the new Statement elaborates by stipulating that there be some certainty that the regulatory agency will find those AFUDC costs to be allowable.

On October 26, 1987, the FASB released for public comment a proposed Technical Bulletin intended to clarify an example in FASB Statement 90 entitled "Regulated Enterprises — Accounting for Abandonments and Disallowances in Plant Costs," relating to the computation of a loss on an abandonment. FASB Project Manager Paul R. LePage notes that "the proposed Bulletin states that the example in question does not accurately reflect the intent of Statement 90 and proposes a new example that would reflect that intent." The FASB is expected to issue a final Technical Bulletin before the end of the year that gives examples for computation of a loss on an abandonment.

Phase-In Plans — Statement 92

When a utility completes the construction of a new power plant, conventional rate-making methods establish rates to recover the allowable costs of the plant. These allowable costs include current operating costs, depreciation, interest on borrowed funds invested in the plant, and an allowance for the utility based on a reasonable profit margin. The latter is intended to represent a "fair rate of return" on shareholders' investment in the plant. Because of the vastly increased costs in building power plants in recent years, particularly nuclear plants, the initial inclusion of construction costs into the rate base when the plant begins service can result in "rate shock", or sharp increases in rates because of the sudden inclusion of the costs of a new plant. Phase-in plans have been formulated as perhaps the best way to mitigate the effects of rate shock. Under such plans, part of the current operating costs related to a new plant that normally would be recovered through current rates are instead deferred for recovery in future years, so that the recovery is made over a given period of time in the interests of maintaining customers' rates at a reasonable level.

On August 13, 1987, the FASB issued the second amendment to Statement 71, through its Statement 92. Statement 92 specified the manner in which utilities should account for costs deferred by regulators under phase-in plans. The Statement applies to utilities that have either completed or performed "substantial physical construction" of plants by January 1, 1988. Furthermore, the new standard specifies four criteria that must be met in order for the capitalization of the costs to be acceptable.

1. The formal plan must be agreed to by the regulator;
2. The plan must specify when the complete recovery will occur;
3. All allowable costs deferred under the plan must be scheduled for recovery within 10 years of the date when deferrals begin; and
4. The percentage increase in rates in a given year must not be greater than the percentage increase in the previous year. This requirement prevents "backloading", or scheduling a small portion of the costs in the first few years while deferring the bulk of the costs to the later years of the plan, effectively postponing rate shock instead of avoiding it.

If any of the above criteria are not met, allowable costs deferred under the plan could not be capitalized, or listed as an asset for financial reporting purposes. Thus, it is in the interest of the utility to establish a phase-in plan that meets all of the necessary criteria.

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Industry Reactions

The FASB allowed public comment on the preliminary standards by releasing an "Exposure Draft" in December 1985 and holding a public hearing in June 1986 (see Report 214, June 1986, page 16). The Exposure Draft covered all of the issues that eventually comprised both Statements. At the time of the hearing, there was a great deal of controversy over the drafts, as a record number of participants commented on the proposed revisions. However, for the most part, the final Statements differed little from the original draft; the issue of phase-in plans was removed and handled in a separate manner, resulting in the issuance of two Statements. Both Statement 90 and Statement 92 become effective for fiscal years beginning after December 15, 1987.

There still exist a variety of opinions regarding the new standards. Some industry participants are disenchanted by the fact that Statement 92 requires either all or none of the allowable costs to be capitalized, depending upon whether the specific criteria are met. While some observers viewed the ten-year phase-in requirement as arbitrary and unrealistic, others felt it would help restore credibility to utility financial reporting. The latter argued that the concept of utility bankruptcy is a possibility in some situations, and many believe that financial risk associated with new nuclear plants should be accurately represented on a utility's balance sheet.

Reactions to Statement 90 generally have been more vocal because of the immediate and direct influence it will have on earnings and shareholders' investment. Moreover, the sometimes arbitrary nature of PUC disallowances has placed some utilities in the position of defending purchases or construction costs that may have been standard at the time they were incurred, but are not prudent in today's context. Utilities are therefore concerned that unfavorable PUC decisions made in hindsight will be magnified by the new FASB standards and will adversely affect bond and credit ratings, investment potential, and common stock value.

It is likely that the risks of subjecting earnings and shareholder rewards to decisions from PUCs, implemented through the new standards, will continue to discourage utilities from constructing new nuclear units. The lack of orders for new units in the USA is at least partially due to the likelihood that some portion of construction costs will be retroactively found to be imprudent, for reasons such as high construction costs or existing excess capacity. The fact that the new FASB standard requires such liabilities to be recognized all at once rather than over time is likely to be a further indication to utilities that nuclear construction is a high-risk venture.

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RADIOMETRIC ORE SORTING

Introduction

Since the late 1950s, uranium ore has been sorted using radiation monitoring equipment to distinguish between ore grades. Sorting may be applied to individual pieces of ore or to bulk units such as truck loads. While this article focuses on the sorting of individual pieces, most uranium mines, surface and underground, use some type of radiation scanning equipment to classify bulk units into two or more categories. Doing this helps identify waste and minimizes mill head grade fluctuations by blending stockpiled material to increase uranium recovery.

There are many reasons for sorting, or preconcentrating, ore to be milled, but the primary one is to reduce overall production costs. This is normally accomplished by using sorting to increase the grade of ore, by discarding low grade ore and waste. The primary advantages include:

1. Reduced ore transportation costs — particularly where ore must be transported considerable distances, sorting at the mine site has the potential to greatly decrease transportation costs for a given amount of uranium output.

2. Increased mill utilization and lower costs — providing sorted, i.e. upgraded, ore for milling results in increased output. The higher grade throughput means lower extraction costs, or perhaps a smaller milling facility to achieve the same output.

3. Increased reserves — by relying on sorting to allow the mining of lower-grade ores (lower "cutoff" grade) a project's reserves can be expanded and the life of the project prolonged.

4. Lower reclamation costs — sorting can potentially decrease the quantities of tailings produced in the milling process.

Sorting Techniques

Throughout the history of mining, sorting has been used as the first step in the mineral processing sequence. With modernization, many mechanical and other types of sorting techniques have evolved to replace hand sorting, although hand sorting is still in use at various sites around the world.

Mechanization of the sorting process began with a variation on hand cobbing, by passing ore on a conveyor belt past rows of workers whose job was to accept or reject pieces of the ore or waste rock. The classic reference *Handbook of Mineral Dressing*, by Arthur F. Taggert (copyright 1927) states: "Labor is generally that unfit for any heavier work — boys, girls, women, or old or crippled men. Boys and girls are quicker and, if properly supervised, most satisfactory." From this point, more sophisticated sorting methods have been developed, based on radioactivity,

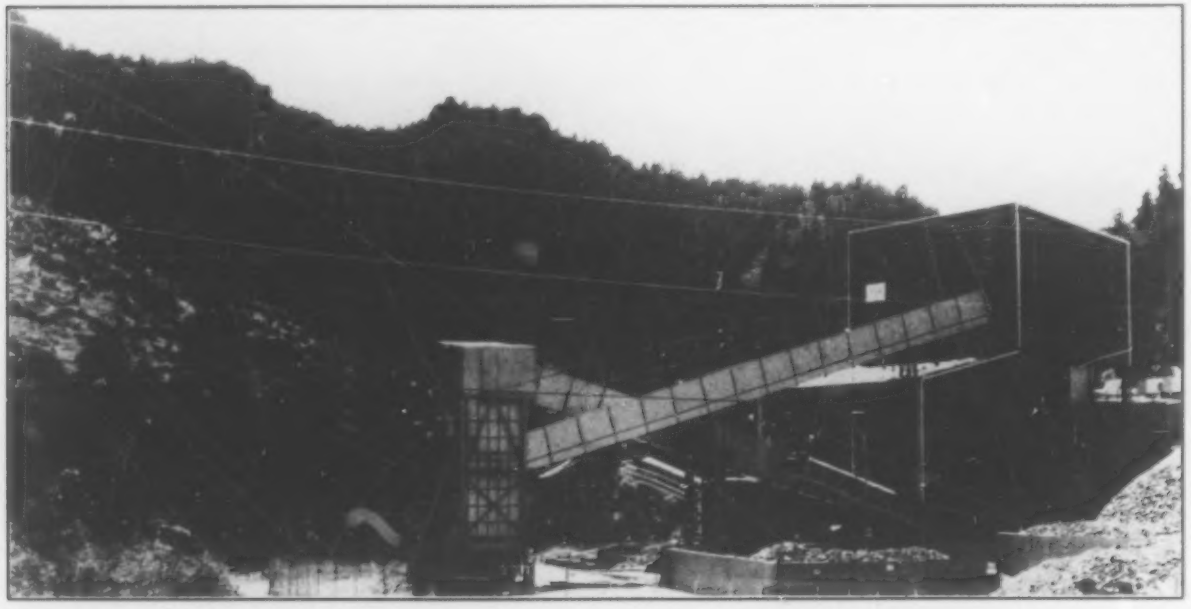

Figure 3. Ore Sorting Plant at the Schwartzwalder Mine, Golden, Colorado, USA.

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optical characteristics, specific gravity, magnetic properties, electrical conductivity, or color differences. For uranium mining, technology based on measurement of radioactivity appears to offer the most potential for fully automated sorting.

History of Radiometric Sorting

Canada's first uranium mine, the Eldorado mine at Port Radium on Great Bear Lake in the Northwest Territories, utilized hand sorting of high-grade uranium/silver ore as early as 1932, during the initial development of the mine. Subsequently, a 36-inch-wide (approximately 1 meter) sorting belt was incorporated into the mill, carrying plus-35mm (1.5-inch) material from a vibrating, heavy-duty screen (grizzly). The ore was sorted into a high-grade concentrate for direct shipment, and a waste product. Intermediate-grade material remaining on the belt was further processed by leaching to produce precipitated concentrate. A Geiger counter installed above the belt aided the sorting.

By the late 1940s, a device called the Lapointe Picker had been developed in Canada and incorporated the principles upon which today's radiometric sorters are based. The Lapointe unit used Geiger counters to measure gamma emissions from individual rock pieces moving above the counters on a conveyor belt. A drawback to this device was the inability to measure mass of the rocks. In other words, while it was able to measure radioactivity, the machine could not differentiate between a small high-grade rock and a large low-grade rock, and so could not establish a relative radiation level that would provide a more precise basis for selection. This drawback was partially overcome by carefully controlling the size of the feed, even using several of the machines, each sorting different sizes, calibrating them accordingly. The units also encountered problems in positioning the individual ore pieces for reading by the Geiger counters. These early sorters used horizontal pneumatic rams to push larger-sized pieces of the accepted ore from the conveyor belt. Ore particles smaller than approximately 50 mm (2 inches) in diameter were separated by air jets blowing across the conveyor belt.

By 1958, a sorting unit developed by L. Kelly and J. Hutte, called the K and H Model 6, had been installed in Canada at the Bicroft Uranium Mines Ltd. in southeastern Ontario near Bancroft, about 150 miles northeast of Toronto. Kelly and Hutte were employees of Bicroft in the positions of Chief Geologist and Chief Engineer, respectively.

Sorting with the K and H device occured during free fall of the ore from the end of the conveyor belt. Each piece passed a scintillation counter which fed readings to an electronic control system which, in turn, regulated a series of air jets located 18 inches below the counter. Under this system, waste was rejected and ore was allowed to fall freely.

Ultimately, the K and H sorter incorporated several essential improvements, particularly in feed presentation and in the measurement of particle size. The rock was fed into the sorting machine from a surge bin via a conical-shaped rotating feeder, which positioned the ore pieces individually on the conveyor belt. The belt then accelerated the rock to about one meter per second. A light source coupled with a photoelectric cell measured each particle's approximate cross-sectional area while in free-fall, and just below it, a radiation detector measured radioactivity. Feed ranged in size from approximately 50 to 300 mm (2 to 12 inches), and maximum sorter capacity was about 25 tons per hour of plus-75 mm (3 inch) material. In 1960, six of the K and H sorters were installed at the Mary Kathleen Uranium Ltd. Mill in Queensland, Australia. Others also were installed at the Eldorado Mining and Refining Ltd. Beaverlodge Mill in Canada's Northwest Territories.

After the operation of K and H equipment at the Mary Kathleen Mine had proved highly successful, the mine owners, Conzinc Rio Tinto of Australia Ltd., bought the Canadian company, along with a South African firm building sorting equipment under license, forming Ore Sorters Ltd. as a subsidiary of Rio Tinto Zinc Corporation (RTZ). The new company began to make additional refinements to the concepts originally developed by K and H for sorting according to radioactivity, and also developed optical sorting devices.

Another company, Sortex, a subsidiary of Gunson Ltd. of the U.K., also began development of radiometric sorting equipment. Gunson had been supplying automated seed and other foodstuff sorting machinery since the 1940s, as well as supplying sorting equipment to the diamond industry in South Africa. It has been reported that four Gunson Sortex radiometric sorters were sold to the Bufflesfontein Gold Mining Company of South Africa in 1980. Subsequently, this division of Sortex was bought by Ore Sorters, making Ore Sorters the only free-world supplier of radiometric sorting equipment.

At present, units supplied by Ore Sorters have been installed in several working uranium mines, and come in

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several configurations, with varying capacities and other features that accommodate specific mining conditions. The company's manufacturing plant is located at Wynburg, near Johannesburg, South Africa.

Sorting Technology

Radiometric sorting systems almost invariably are placed following the primary crushing process and incorporate a washing/screening operation to eliminate fines from the sorter feed. In addition, all radiometric sorters rely on certain similar subsystems, including:

1. A means of distributing particles separately on a feeder line (ore presentation, Figures 5 and 6);
2. A detection system, which differentiates individual particles, measuring their size (or mass) and radioactivity levels (sensing, Figure 4);
3. A system to eject, or split the ore stream into accepted or rejected fractions (separation); and
4. Electronic coordination of the detection system with the ejection system (electronic processing);

Figure 4. Ore Sorter Radiation Measurement Unit at the Schwartzwalder Mine.

Proper particle distribution along a moving belt is a critical part of the sensing process. Not only must the particles be fairly evenly distributed at an optimum distance apart, but they must be accelerated to a certain velocity so that when they leave the end of the feeder belt, their trajectory is such that they can be deflected by air jets into one of two piles. For radiometric sensing, the rocks must be positioned in single file, not in a random sequence, for reading by the radiation detection equipment and the optical size detectors, which together determine rejection or acceptance. The speed of the particles on the belt is precisely correlated with the sensing devices, and rock position must be effectively stabilized while on the belt. In most sorters, a surge bin or feeder belt feeds the ore into channels on the scanning belt; its acceleration to around 5 meters per second causes the particle spacing to increase.

All radiometric sorters have measured particle radiation with scintillation counters ("scints"). While the early K and H sorters measured particle radiation as the rock piece was falling free after leaving the conveyor belt, current practice, as used in the Ore Sorters Model 17 unit, is to place the scints below the moving belt. Different arrangements of sensors are used depending on the rock sizes being measured. Lead shielding around the scints prevents outside radiation interference. Depending on the actual equipment used, an ore particle may pass over as many as sixteen scints, which register and total the radiation count before it is collated by the central processer.

One of the problems with early sorting technology was the crude, or nonexistent, determination of particle mass. Without a reasonably accurate mass determination, the gross radiation count could not be precisely correlated with rock size to give a true evaluation of ore grade. Again, using the Ore Sorters Model 17 as an example, mass determination is now performed by a row of photodiodes that measure the size of a shadow cast by a light source as the rock piece moves past the sensors while in free fall.

Input data, such as the values for radioactivity, estimated particle size, and belt speed, are stored in the sorter's computer processor, where the decision is made to accept or reject the particle, based on a predetermined grade cutoff level. The computer then relays instructions to a blasting manifold that directs compressed air at the computed location of the particle to be blasted.

The blast of air determines the trajectory taken by the particle leaving the moving belt, directing it to one side of a splitter or the other. The sorter can be directed to blast either an accepted or rejected fraction, depending on which

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is more economical. Normally, the smallest fraction of the ore (whether accepted or rejected) is the one blasted.

At the present state of development, certain physical limitations hinder the application of sorting equipment. In particular, the size of ore particles must fall within certain limits, generally between 25 and 160 mm (1 to 6 inches), and the different particles must exhibit a reasonable variation in uranium grade.

Sorting machines are available having several different configurations with regard to numbers of channels and capacities of ore. For higher capacities and larger particle sizes, a two channel configuration might be appropriate, with a throughput of about 120 tons per hour. For smaller particle sizes, perhaps in the 25 to 50 mm range, a three, four or five channel system with a throughput of perhaps 50-70 tons per hour might be better suited. The costs of the various configurations are roughly the same.

Figure 5. Surge Bin Feeding plus-75mm (3-inch) Ore to the 2-channel Sorter. (Schwartzwalder Mine)

Figure 6. Part of 6-Channel Sorter, Used for 25 to 75-mm (1 to 3-inch) Ores. (Schwartzwalder Mine)

Suitability of Ore for Sorting

The physical characteristics of an ore determine its suitability for sorting and greatly affect the efficiency of the sorting process. These characteristics include the ore's resistance to breakdown into "fines" and radiological contrast between particles. Visualize, if you will, a barrel filled with a mixture of large, black, heavy marbles and small, white, lightweight cubes. Obviously, such a mixture could be quickly sorted into its components by any of several means, with little or no residual intermingling. As the similarity between components to be sorted increases, the separation becomes more difficult and residual intermingling increases. Residual intermingling is the measure of the efficiency of the sorting process and may be thought of as the combined percentage of misplaced material.

Typically, uranium ores are sorted on the basis of the

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amount of radiation emitted per unit of mass, i.e. its radiometric grade. Thus, the sorting system must be capable of measuring both radiation and mass. To date, all radiometric sorters have used indirect methods to accomplish this. Grade measurements are indirect in the sense that radiation is assumed to be directly proportional to uranium content. The assumption, however, may be far from accurate for many individual rocks, particularly in sandstone deposits, as well as in certain others.

This departure from direct proportionality (equilibrium) is termed disequilibrium and is caused, generally, by preferential leaching or deposition of some or all of the uranium decay products associated with the original deposit. These products of uranium decay are the primary emitters of the gamma radiation which serves, typically, as a measure of the quality (grade) of uranium ore. Most of the gamma-ray emission of uranium ore can be attributed to Thorium 234, Lead 214 and Bismuth 214. When the rate of formation of these elements is not equal to the decay rate, the deposit is not in "equilibrium" and the quantity of uranium present is not proportional to the radiation emitted. In such cases, a radiation scanner is unable to sort effectively.

The determination of mass (or weight) is also indirect. Most current systems utilize a light source and an array of photocell detectors to measure the shadow produced and hence to estimate the size or volume of each particle. For ore of constant density, the method provides sufficient definition. For ore with varying density (in many cases, density varies with grade), the process is less effective.

The physical act of transporting and handling ore generates a substantial amount of fine particles through attrition. Most sorters can handle a size range of between 25 to 150 mm (1 to 6 inches); for purposes of definition, fines are considered as being less than 25 mm (one inch) in size. Since sorter capacity is a function of pieces throughput per unit of time, a given machine can sort more tonnage per unit of time when sorting larger material. Ores which are resistant to breakdown from abrasion may, therefore, be more efficiently sorted.

Sandstone uranium ores tend to be friable and to contain clay. They break down easily when handled (an advantage for conventional milling operations) or when exposed to air and water. The clay content, which can cause a variety of handling and treatment problems for conventional mills, also can cause major problems for sorting, especially in the screening/washing sequence. Overall, sandstone ores, which comprise over 90 percent of the world's uranium resources, are not particularly suitable for sorting.

Ores which exhibit a wide range of uranium content are more amendable to efficient sorting than those with a narrow range, because the wider range provides a greater contrast. Particular difficulties are encountered if a large percentage of the ore is near cut-off grade. In this case, minor deficiencies in the sorting process could lead to greatly increased residual intermingling.

Projects Using Radiometric Ore Sorting

Australia

The Mary Kathleen Mine — The Mary Kathleen mine was located 40 miles east of the mining town of Mt. Isa in western Queensland. Uranium deposits of this area occur as ore shoots in massive garnet diopside which is hard, abrasive and dense. The uranium mineralization is pitchblende in allanite and varies in thickness from a few centimeters to several meters.

The original sorting installation at the Mary Kathleen consisted of five Model 6 sorters of the early K and H type. These sorters were installed in 1960. In 1979, two Model 17 sorters were added in order to increase throughput and reduce uranium loss to rejects, particularly in the finer material. Mined ore grade averaged about 0.10 percent U_3O_8. After crushing, the plus 100 mm (4 inch) material was washed to remove fines and then sorted. By rejecting about 20 percent of the feed, the average mill head grade was raised by about 10-15 percent The grade of the material actually sorted was raised by about 50 percent.

The Mary Kathleen mine operated from 1958 through 1963 and from 1974 to 1982. The plant had a design capacity of 3,000 tonnes per day of mine-run ore. The entire operation has been decommissioned and reclaimed to the extent that the Queensland government has now accepted termination of the mining leases and has assumed full responsibility for any long-term effects.

Canada

Bicroft — The uranium-bearing rocks of the Bancroft area occur in pegimatitic granite dykes, the only such economic occurence in pegmatites in Canada. Uranium deposits of the district are generally of low grade. In 1981, the average grade of Bancroft area reserves was estimated to be 0.11 percent U_3O_8. Uranium occurences in pegmatites are notably irregular and, given the general hardness of pegmatites, provide an ideal setting for the sorting process.

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The K and H sorter installed at the Bicroft mill in 1958 sorted plus 75mm (3-inch) material at a rate of 20 tons per hour. After crushing, screening and washing, the ore was fed onto a conveyor belt traveling at about 1 meter per second. The mine's average feed grade was 0.03 percent U_3O_8, and the sorter rejected 65 percent of the feed with an average grade of 0.011 percent U_3O_8. The remainder of the ore was upgraded to 0.065 percent U_3O_8. This sorter was set to blast waste even though the majority of the feed was waste. The reason for blasting the waste fraction instead of the accepted ore was to maximize uranium recovery. The overall uranium recovery was about 75 percent.

Total mill operating costs were reported to be C$3.662 per ton of ore for the period January to June 1958. Updated to 1987 Canadian dollars through the Industry Selling Price Index, 1987 costs would be about C$14.80 per ton. At a rejection rate of 13 tons per hour, the annual savings could be substantial. Actual savings are difficult to calculate since sorting costs are included in the total milling cost and since fixed and variable costs, pre- and post-installation recoveries and the time value of money all affect the calculation.

France

Lodeve — At Lodeve, in the south of France, Cogema installed a radiometric sorter at its existing plant in 1985. The ore is described as a highly-compacted, fine, detrital sandstone with an average grain size of 60 microns. Mineralization may occur either as fracture filling or as large zones within more permeable beds.

The Lodeve sorter is a four-channel unit which rejects about 20 percent of its throughput. Feed to the sorter ranges in size from minus 90 mm (3.5 inches) to plus 30 mm (1.25 inches). Rejected grade is about 0.04 percent U_3O_8. The average mined ore grade is 0.30 percent U_3O_8.

South Africa

Radiometric ore sorting has been applied at several gold mining operations in South Africa where the gold content of the ore is roughly proportional to the uranium content. These ores occur as thin, extensive "reefs" of hard quartz-pebble conglomerates. The primary objective of the sorting process is, however, to increase the gold grade. Uranium is usually a by-product, the sale of which might account for some 5 to 20 percent of the total revenue. Uranium recovery follows gold recovery by leaching of the finely-ground residual material. The Bufflesfontein plant, for example, has a total throughput of about 260,000 tonnes of ore per month, after sorting. Prior to the installation of a sorting plant, hand sorting was utilized to reject about 20 percent of the mine run ore. The sorting plant consists of four six-channel sorters which are designed to reject material grading less than 0.0025 percent U_3O_8.

The Hartebeestfontein mine produces some 4,000,000 tonnes of ore per year, of which in 1987 some 23 percent was rejected by the sorting plant. As direct mill operating costs amount to R 8.50 (US $4.25) per tonne of ore milled, the potential for cost reduction or for increased throughput of more profitable ore can be substantial.

USA

The Schwartzwalder Mine - Cotter Corporation, a subsidiary of Commonwealth Edison, operates the Schwartzwalder uranium mine which is located in the foothills of the Rocky Mountains about 25 miles west of Denver, Colorado (See Figure 3 at the beginning of this article). Ore is sorted at the mine and is trucked some 110 miles (180 km) to Cotter's mill at Canon City, Colorado. Thus, transportation savings are a major factor in the sorting economics.

Uranium mineralization at the Schwartzwalder occurs primarily in fissure veins along faults and fractures in metasediments and crystalline rocks. Disseminated mineralization in pegmatite dikes is of minor importance. The principal uranium minerals are pitchblende and coffinite. The ore is relatively hard but does have a tendency to break into fines; the waste is less brittle. As a result, recovered grade is not greatly reduced by allowing the fines to bypass the sorter and go directly to the ore stockpile.

Two radiometric sorters were installed in 1977; a three-channel and a six-channel unit. The three-channel unit is used for larger particles (50 to 150 mm) and the six-channel unit is used for smaller (25 to 50 mm) sizes. These units have accumulated 63,000 and 28,000 operating hours, respectively, since installation. Maximum throughput was 130,000 short tons in 1979.

Historically, the Schwartzwalder mine has produced a mine-run grade of about 0.30 percent U_3O_8, which has been upgraded by sorting to about 0.50 percent U_3O_8. The reject rate has been about 30 percent of throughput when sorting out rock of 0.02 percent U_3O_8 or less. More recently, both the mine-run grade and sorted grade have been increased in order to cope with falling prices.

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Energy Fuels — Energy Fuels Nuclear Corp. has used a portable radiometric ore sorter on low-grade material stockpiled at its breccia-pipe Hack Canyon mine near the Grand Canyon in Arizona. In this case, the ore is a cemented breccia of various sediments including sandstones, shales, and limestones. Mineralization tends to be concentrated in the more porous hosts. The Energy Fuels operation is notably remote (300-plus miles) from the mill at which the ore is processed; thus, substantial transportation savings are a potential result of sorting. It may be speculated that sorting could be applied to other uranium deposits, developed or undeveloped, which are remote from a mill. In this way, potential licensing problems for a new mill can be minimized or avoided.

Sorting Economics

The primary benefits of sorting may be seen in reduced costs for mill operation and transportation. Sorting may also provide opportunities for increased mill output, longer project life, lower reclamation costs and increased mill recovery. Certain of these benefits could easily be additive and may provide new perspectives for a number of uranium deposits.

Mill Operating Costs

The recovery of uranium from mined ore normally requires a series of unit process operations including crushing, grinding, leaching, liquid/solid separation, precipitation and waste disposal. The cost of most of these operations depends on the tonnage of ore treated, not on the quantity of uranium recovered. These costs are composed of two elements: fixed items which are more or less independent of throughput, such as labor, and variable items such as chemicals and power supplies, which are directly dependent upon throughput.

Fixed costs may amount to about 40 percent of direct operating costs. Thus, if mill throughput could be reduced 25 percent by sorting, the total mill operating cost might be reduced by 15 percent (60 percent x 25 percent). This reduction would be offset, to some degree, by the operating cost of sorting, which has been estimated to be in the range of $1.00 per ton of feed. Thus, for mills with operating costs greater than $7.00 per ton ($1.00/0.15), sorting may offer an economic advantage.

This operating cost advantage must, of course, be weighed against the cost of purchasing and installing the sorter. The process of comparing reduced operating cost against a capital cost usually requires the development of a series of cash flows which may be discounted through time to reflect the cost of money. Decreased overall recoveries must also be considered since some potential product is discarded during the sorting process. Mill operating costs in the western USA range from about $15.00 to $35.00 per ton of ore.

Transportation Costs

The economic impact of sorting on long-distance transportation costs is relatively easy to define. Truck transportation costs in the western USA typically are in the range of $0.08 to $0.12 per ton-mile for highway haulage. Thus, if the combination of distance and cost per ton-mile exceeds the operating cost of the sorting unit, some benefit may be gained, provided that sufficient tonnage is available to offset the cost of purchasing and installing the sorter. Again, sorting losses and the time value of money play a role in the overall analysis.

Mill Size

For new operations, a sorting unit could reduce the size of the processing facility required. A new 1,000 ton per day capacity uranium mill built in the western USA today might cost, for example, $35 million. If the same output could be achieved by a smaller mill (by feeding higher-grade, sorted ore), significant savings in construction costs could result. Table 1 shows an estimate of these savings in relation to decreased capacity. These potential savings can be compared to the cost of purchasing and installing a sorter, which by some estimates might be in the range of $1.5 million.

Looking at mill sizing from the perspective of increased output, the results could be even more significant. Suppose, for example, that a sorter rejecting 20 percent of the mill feed increases the grade of the feed by 25 percent. Mill output and revenue would be increased by 50 percent.

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Table 1

RELATIONSHIP OF SORTED FEED TO POTENTIAL MILL CONSTRUCTION COST SAVINGS

Percent Feed Sorted and Rejected	Construction Cost Savings ($Millions)
5	1.1
10	2.1
15	3.3
20	4.4
25	5.6

Conclusion

The production cost savings potentially available through use of radiometric sorting of uranium ore are substantial, but many ores, especially most sandstones, are not well suited to sorting. Installing a sorting plant is not cheap — between one and two million dollars including purchase, setup, and the necessary modifications to an existing plant. Sorting technology continues to evolve, however, toward the capability of handling smaller particles and evaluating their grade more accurately. Sorting plants are likely to plant an increasing role in the future development of the uranium industry.

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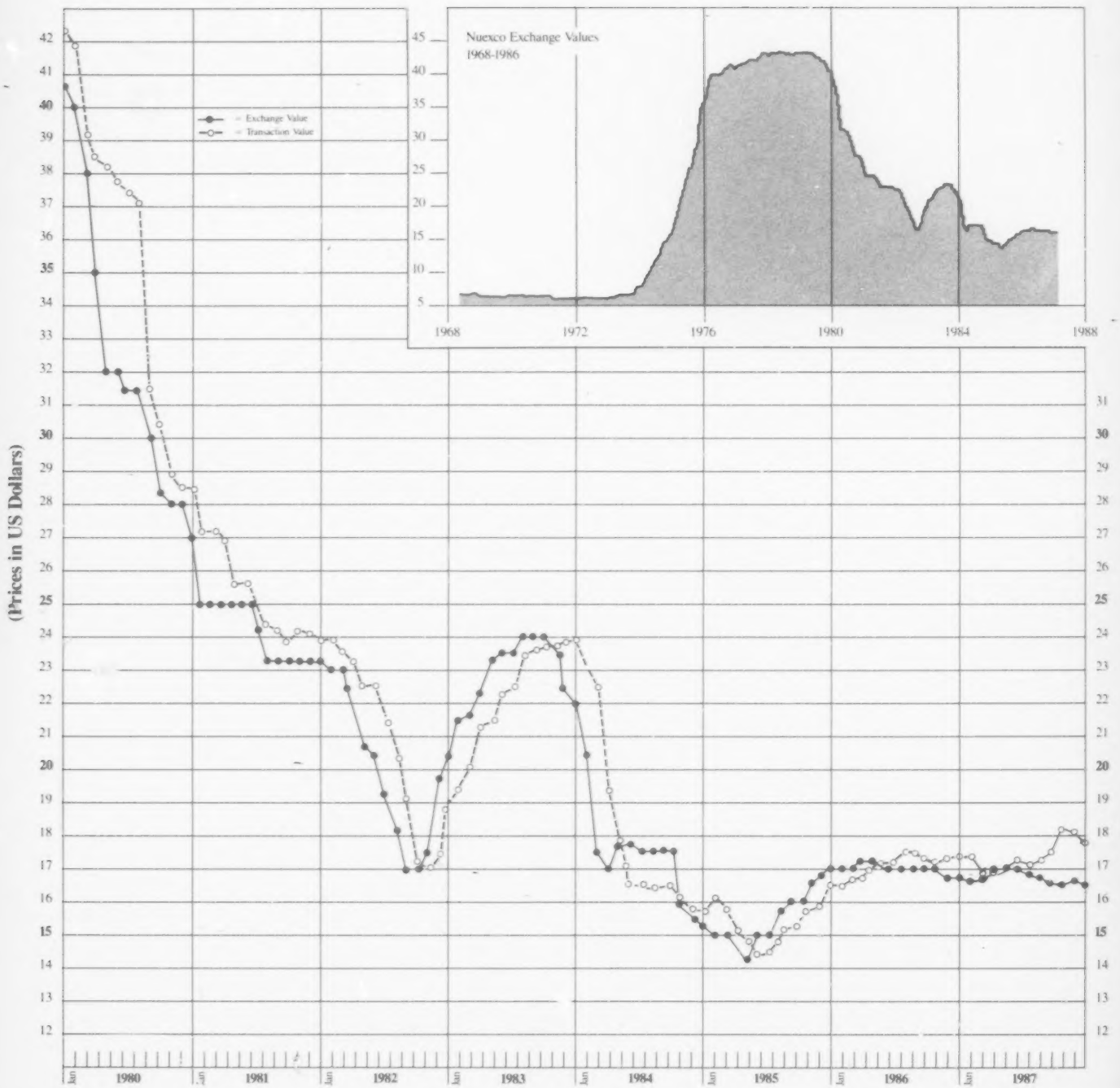
Nuexco Exchange Values
1968-1986
1968
1972
1976
1980
1984
1988
= Exchange Value
= Transaction Value
(Prices in US Dollars)
Jan 1980
Jan 1981
Jan 1982
Jan 1983
Jan 1984
Jan 1985
Jan 1986
Jan 1987

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HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969		6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	16.65	16.65	16.75	**16.65**	

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.30	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.05	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	17.55	18.20	18.05	**17.80**	

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HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.90	**1.90**	

HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	47.00	46.75	47.00	**47.00**	

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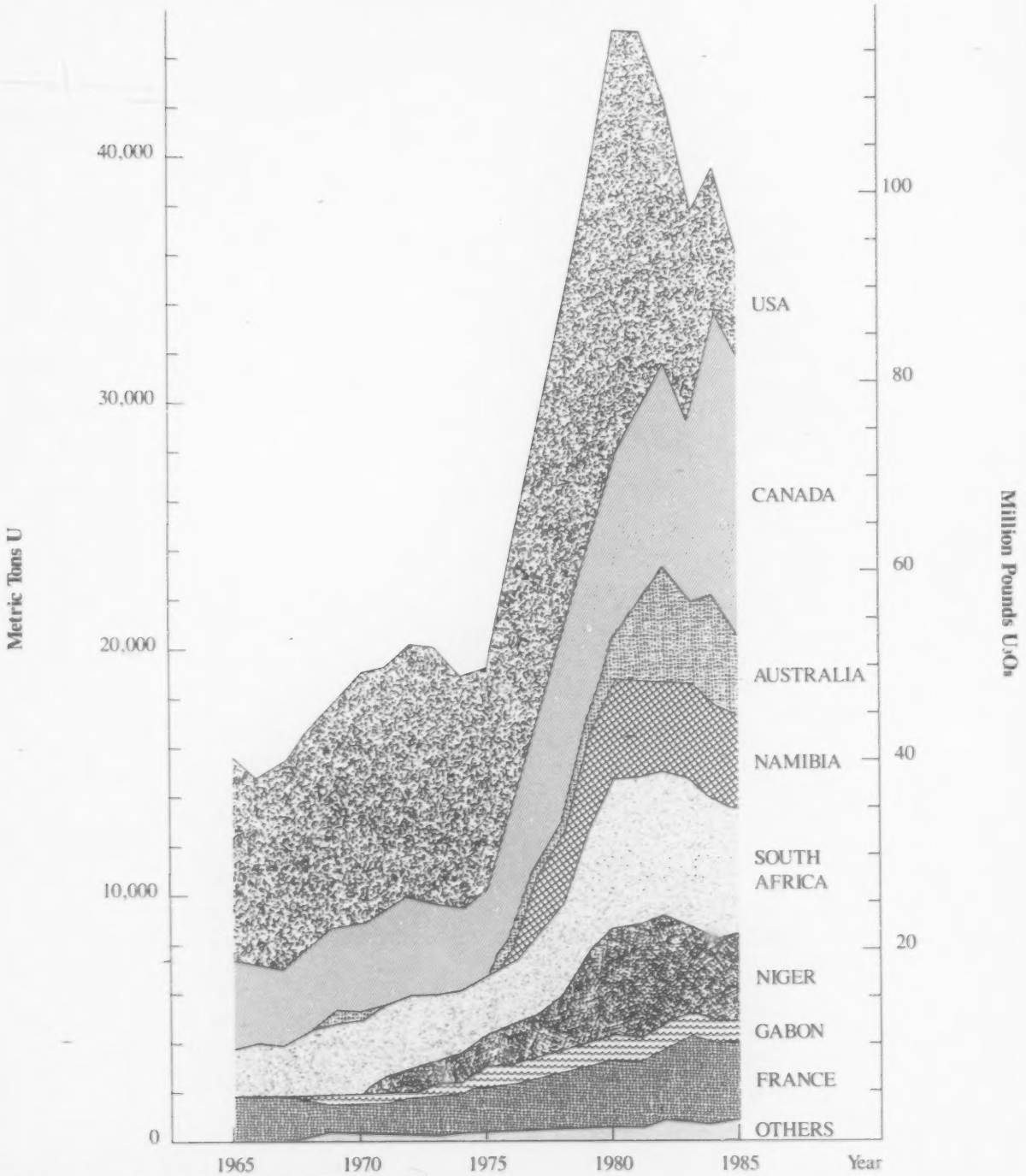
HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



[1]WOCA = World Outside of Centrally-planned Economic Areas.
[2]1985 production data are preliminary.
[3]A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

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US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3
1986	13.5	18.9	$30.01	13.5	$20.07	1.6

[1]Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Rresources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, ASsistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2]Sources: 1976-11982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3]Excludes direct imports by domestic utilities.

[4]Includes imports by domestic utilities and domestic suppliers.

[5]Includes delivery commitments to domestic utilities and agents.

[6]Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

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HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00
1986	12,000	9.5	ECU 31.50	$31.00	ECU 18.00	$17.75

[1]The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EEC.

[2]The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3]For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4]Exchange rates are published by European Communities Statistical Office and the International Monetary Fund.

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AUSTRALIA

		Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2]	Award Rates of Pay Indexes Australia - Adult Males In Mining Wage Earners, Weekly Rates[3] (1976=100)
1975	Avg.	57.9	150.4	132.6
1976	Avg.	65.7	168.4	160.9
1977	Avg.	73.8	192.0	179.0
1978	Avg.[4,5]	79.7	198.5	190.0
1979	Avg.	86.9	248.8	127.9
1980	Avg.	95.8	321.8	140.8
1981	Avg.	105.0	355.3	154.1
1982	Avg.[6]	116.7	368.6	174.9
1983	Avg.	128.5	401.6	181.9
1984	Avg.	133.6	95.3	194.4
1985	Avg.	142.6	100.0	202.7
1986	Avg.	155.5	105.0	212.9
Jan	1986	—	109.5	210.5R
Feb	1986	—	108.7	210.5R
Mar	1986	150.5	99.4	210.5
Apr	1986	—	94.2	210.5
May	1986	—	93.5	210.5
Jun	1986	153.0	95.6	210.5
Jul	1986	—	97.8	215.3
Aug	1986	—	97.9R	215.3
Sep	1986	157.0	105.4	215.3
Oct	1986	—	105.9	215.5R
Nov	1986	—	104.9	215.7R
Dec	1986	161.5	105.2R	215.6
Jan	1987	—	106.2	215.9R
Feb	1987	—	108.9	216.5
Mar	1987	164.7	108.4	222.2R
Apr	1987	—	108.3	222.1R
May	1987	—	108.1	221.9R
June	1987	167.2	108.1	221.2R
July	1987	—	108.7	222.5R
Aug	1987	—	110.5	223.2R
Sep	1987	170.0	—	223.3

P = Preliminary R = Revised since last month

[1]Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81=100.0). Index periods are for normal calandar years; figures shown at tnd of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. the previous index was 1969 = 100.

[3]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4]Annual Averages are for financial year ending June 30.

[5]Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[6]Monthly data for 1979-82 appear on page 35 of Report 184.

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GOVERNMENT STATISTICS

CANADA

			Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Industry Products Price Index: All Commodities[1] (1981 = 100)	Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979	Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980	Avg.	247.2	—	10.58	10.80	—	—	8.50
1981	Avg.	288.7	—	12.02	12.23	—	—	9.53
1982	Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983	Avg.	298.8	—	—	14.30	—	—	11.17
1984	Avg.	310.9	17.88	—	—	—	—	—
1985	Avg.	118.58	18.52	16.37	15.65	12.75	11.19	12.20
Jan	1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb	1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar	1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr	1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May	1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun	1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul	1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug	1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep	1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct	1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov	1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec	1986	119.7	19.67	16.79	16.19	13.06	11.57	12.99
Jan	1987	120.0	19.53	16.93	16.01	13.06	12.58	12.89
Feb	1987	119.8	20.33	17.20	16.21	13.01	12.66	13.11
Mar	1986	120.4	20.04	17.14	16.15	13.57	12.58	13.02
Apr	1987	121.2	20.47	17.38	16.26	13.75	11.99	13.27
May	1987	122.0R	20.50	17.12	15.96	14.23	11.44	13.19
June	1987	122.5	20.23	16.94	15.70	13.65	12.77	12.88
July	1987	123.1	19.75	16.73	15.63	13.90	12.52	12.98
Aug	1987	123.7	19.64R	16.98R	15.87R	13.99R	12.65R	13.03R
Sep	1987	124.0	18.66P	17.17P	16.19P	13.71P	12.52P	13.28P
Oct	1987	124.3	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (3Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)"Æ Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, plus a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data. Wage Earner Data were further revised in January 1987 and now reflect a slightly different base than previously.

[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4]Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5]Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6]Monthly ISPI data for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7]Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)".

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REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.[7]	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.88	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.76	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	740,031	532,577
Feb	1987	—	—	251.0	237.0	757,872	598,986
Mar	1987	88.17	197.1	255.0	239.6	762,697	536,006
Apr	1987	—	—	258.2	242.5	761,850	533,487
May	1987	—	—	261.2	243.6	759,421R	530,981
Jun	1987	90.74	203.5	263.1	244.9	759,433	573,546
July	1987	—	—	266.2	246.8	681,409	566,232
Aug	1987	—	—	270.0	249.9		
Sep	1987	100.79	224.7	273.4	252.4	—	—

P = Preliminary R = Revised since last month

[1]Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly.
[2]Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.
[3]Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."
[4]The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.
[5]Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.
[6]Bulletin of Statistics, Department of Statistics, Pretoria.
[7]Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.
[8]Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157
[9]Monthly data for 1979-82 appear on page 39 of Report 184.

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GOVERNMENT STATISTICS

UNITED STATES

		Producer Price Index[1]		Consumer Price Index[2] (1967 = 100)	GNP Implicit Price Deflator[3,4] (1982 = 100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
		Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)			Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.[6]	274.8	268.8	246.8	85.7	10.26	10.63	8.30	6.94
1981	Avg.	304.1	293.4	272.4	94.0	11.55	11.98	9.12	7.62
1982	Avg.[7]	312.3	299.3	289.1	100.0	12.31	12.93	9.96	8.21
1983	Avg.	315.7	303.1	298.4	103.9	12.58	13.43	10.59	8.65
1984	Avg.	322.6	310.3	311.1	107.7	13.05	13.43	11.08	9.04
1985	Avg.	323.8	308.7	322.2	111.2	13.38	13.74	11.56	9.46
1986	Avg.	312.2	299.8	328.4	114.1	13.20	13.49	11.98	9.65
Jan	1986	323.8	308.9	328.4	—	13.41	13.68	11.87	9.58
Feb	1986	318.9	304.4	327.5	—	13.46	13.80	11.83	9.57
Mar	1986	314.0	300.3	326.0	112.9	13.41	13.91	11.80	9.60
Apr	1986	311.6	298.2	325.3	—	13.47	13.89	11.84	9.60
May	1986	311.6	299.2	326.3	—	13.40	13.79	11.90	9.63
Jun	1986	311.8	299.0	327.9	113.7	13.50	13.50	11.95	9.59
Jul	1986	308.5	297.4	328.0	—	13.33	13.30	12.05	9.67
Aug	1986	307.9	297.2	328.6	—	12.96	13.13	11.99	9.64
Sep	1986	308.7	297.5	330.2	114.7	13.04	13.28	12.03	9.70
Oct	1986	309.6	298.4	330.5	—	12.85	13.16	12.08	9.67
Nov	1986	309.8	298.7	330.8	—	12.75	13.14	12.17	9.73
Dec	1986	309.8	298.1	331.1	114.9	12.70	13.03	12.20	9.82
Jan	1987	313.5	300.9	333.1	—	12.94	12.98	12.18	9.84
Feb	1987	314.9	302.2	334.4	—	12.99	12.83	12.21	9.84
Mar	1987	315.7	302.7	335.9	116.1	13.04	12.79	12.24	9.84
Apr	1987	317.3	305.0	337.7	—	13.16	12.90	12.30	9.82
May	1987	318.3	307.1	338.7	—	12.97	12.92	12.31	9.83
Jun	1987	319.9R	308.2R	340.1	117.2	13.05	12.93	12.27	9.84
Jul	1987	322.6	310.2	340.8	—	13.06	13.07	12.37	9.89
Aug	1987	323.8	310.5	342.7	—	13.03R	13.07P	12.34R	9.90
Sep	1987	323.3	310.4	344.4	117.8	13.21P	13.54P	12.56P	9.98P
Oct	1987	324.9	311.4	345.3	—	—	—	12.49P	9.96P

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4]The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6]Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28 and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139. Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147. Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154. Monthly Data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7]Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

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